See Page Mr. 48

COPY FOR MR. J. ALLAN ROSS

HYDRO-ELECTRIC INQUIRY COMMISSION

ENGINEERING DATA

THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT

CHAPTER "M"—DISCUSSIONS

WALTER J. FRANCIS & COMPANY

CONSULTING ENGINEERS

Chapter M.

DISCUSSIONS

Walter J. Francis.

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LIST OF ILLUSTRATIONS

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LIST OF ILLUSTRATIONS

COPY

Chapter M.

DISCUSSIONS

Walter J. Francis

Under the heading of "Discussions", for which provision was made in the original plan of the studies of the engineering data of the Queenston-Chippawa Power Development, we are including a number of subjects which relate more particularly to an analysis of the cost of the work, following the wishes of the Commission expressed verbally and in writing. In a general way the subjects divide themselves on the one hand into an analysis of the actual expenditures in wages paid and in materials purchased, while on the other the discussion may be said to be a comparison between the estimates made prior to construction and the cost of the development as constructed or as it probably will be completed.

The figures used in the discussions are based upon the actual records of the cost of the work up to March 31st, 1922, all as set out in detail in "Chapter K - Costs, Analysis of Expenditures to March 31st, 1922". Where these figures could not be used as a whole, the necessary explanation is made in the text in regard thereto.

An Analysis of Expenditure for Wages.

Amount Paid for Wages.

The total amount paid for wages up to December 31st, 1921, is $19,896,657.53.

This amount includes the wages of all the workmen, walking bosses, foremen and sub-foremen; but it does not include any wages of those engaged on the work in a position above that of walking boss, nor the wages of any of those employed in administrative field overhead work, nor of those in the head office.

The records concerning the payments made are very complete, and have been systematically analyzed as the construction work progressed. When we commenced our studies in April, 1922, the analysis had not been completed up to March 31st, 1922. We therefore made use of the analysis up to December 31st, 1921, as it had been completed. Furthermore this date marked not only a very definite stage of the construction procedure, namely, the admission of water into the canal and the placing of Unit No. 1 in commission, but it included practically all of the wages and expenditures as set forth in "Chapter K - Analysis of Expenditures". The difference is so small that the principle of the present discussion is not affected.

The workmen were paid fortnightly, and on the diagram entitled "Analysis of Wages Expenditure", included herewith as page M-3, the amounts of the pay sheets have been plotted from May 1st, 1917, to March 31st, 1922, the curve thereof being the uppermost curve on the diagram. This curve shows the disbursements in point of time.

Increase in Rate of Wages.

As above stated, the analysis of the wages expenditure has been made up to December 31st, 1921.

From a study of the records of the Cost Department of the Hydro-Electric

Only manner involves the wages of air-ship workers, welfare funds, flying and non-flying, for it does not include any wages of other employees in the work. In a position where that of military bread, nor the wages of any of those employed in administrative field (medical corps, not of those in the land activity.

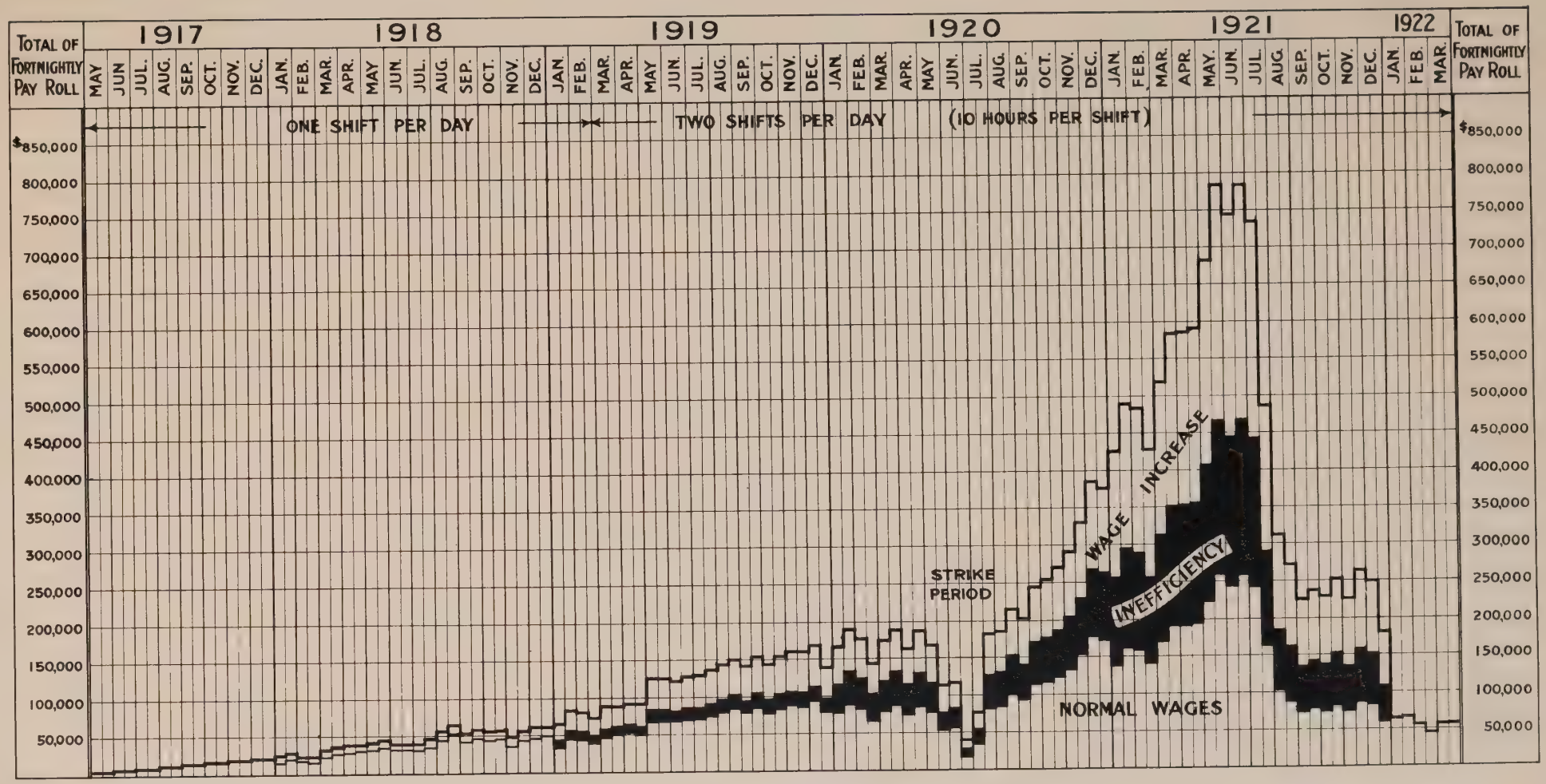
The records concerning the payments made are very analytic, and have been systematically analyzed in the accompanying work sheets. When we compared the months in April, 1920, the analysis had not been completed up to June 21st, 1920. We therefore made use of the analysis up to December 31st, 1919, as it had been completed. Furthermore this data contained but only a very definite range of the probabilities concerned, namely, the relation of water lost to mass and the plotting of that data in graphical form, but is included primarily all of the means and approximations as use made in Chapter X - Analysis of Ge-ometry". The difference is so small that the polarity of the pressure dimension is not affected.

The minimum wire pull difficulty, was in the figures written "analysis of data Capability", Twelfth Lowell in June 1st, the amounts of the 30th which they been quickly from July 1st, 1917, to March 31st, 1920, the curve figured 1-1ar the equivalent force in the diagram. This curve shows the dis-tribution in point of time.

Changes in Cost of Labor.

In other words, the analysis of the wages accumulative time that made up to December 31st, 1920.

Then a block in the records of the Chief Engineer of the Air-Craft.



NOTE –

TOTAL WAGES PAID UP TO DECEMBER 31ST, 1921 . . . . . $19,896,657.53

AMOUNT DUE TO WAGE INCREASE . . $6,943,295.37
AMOUNT DUE TO INEFFICIENCY 4,423,142.96
AMOUNT OF NORMAL WAGES 8,530,219.20 $19,896,657.53

HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
QUEENSTON-CHIPPAWA POWER DEVELOPMENT

ANALYSIS OF WAGES EXPENDITURE

Toronto, July 27th., 1923. Made by S.R.W., Checked by W.J.F.

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

(M-3)

Power Commission at Niagara Falls, Ontario, we have been able to determine the proportion of the wages expenditure which was due to the increase in the rate of wages of the various classes of workmen from May 1st, 1917, to December 31st, 1921, as compared with the 1917 rates. This amount has been found to be $6,943,295.37, and its distribution is clearly shown in the diagram on page M-3 in relation to the total wages paid.

The diagram on page M-5 hereof shows the rate of wages for various classes of labour paid by the Hydro-Electric Power Commission on the Queenston-Chippawa Power Development. For the sake of clearness this diagram is on two separate pages, the second of which is page M-5a, distinguished by the subscript letter "a".

As further information on the subject of wages, the diagram included herewith as page M-6 shows the rate of wages for various classes of labour as paid by the Department of Railways and Canals, Canada, on the Welland Ship Canal.

Page M-7 gives a set of curves of wage rates indicating prices based on the records of the Department of Labour of Canada.

Inefficiency of Labour.

An important factor in the amount of the wages expenditure is that of the inefficiency of labour. In this regard the records of the Cost Department of the Hydro-Electric Power Commission are very complete. The information on this subject in the technical press of America is voluminous, and it has been discussed widely even in the daily papers. The Hydro-Electric Power Commission records are so complete in this regard that the amount can be determined with precision, but the task would be a most laborious one and would require the very

Lower Commissions at Toronto Mills, Ontario, we have been able to determine the proportion of the wages expended here which was due to the increase in the rate of wages of the regular classes of workmen from July 1st, 1917, to December 31st, 1920, as compared with the 1917 rates. This amount has been found to be $4,740,000.17, and its distribution in classify given in the diagram on page M-5 in relation to the total wages paid.

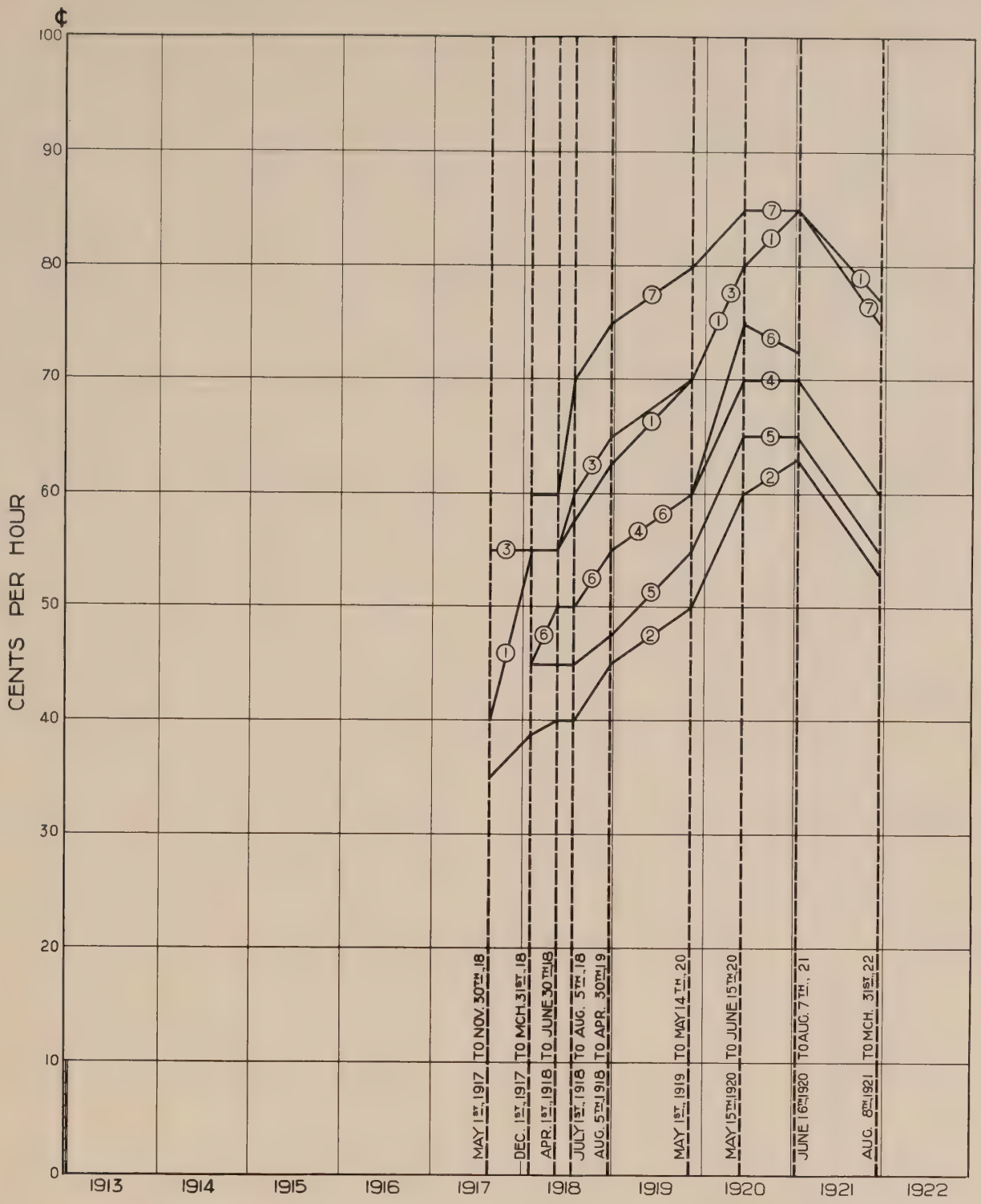
The diagram on page M-5 hereof shows the rise of wages for various classes of labour paid by the Pulp-Industry these Commissions on the Commission-diagram these Commissions. The rise made of diagram this diagram is on the separate page, the second of which is page M-6, distinguished by the schedule letter "C".

As further information, the actual of wages, the diagram included herewith on page M-6 shows the rate of wages for various classes of labour as paid by the Department of Railways and Canals, Canada, on the Welland Ship Canal.

Page M-7 gives a set of average of wage rates indicating prices based on the records of the Department of Labour of Canada.

Inefficiency of Labour.

An important factor in the analysis of the wages expenditure is that of the inefficiency of labour. In this regard the records of our Pulp Department of the Pulp-Industry Power Commissions are very complete. The information on this subject in the Industrial Power of Canada (4 volumes), has it has been discussed verbally with the Pulp Society. The Pulp-Industry Power Commissions' records are so complete in this respect that the amount can be determined with precision, but this task would be a very laborious one and would employ the very



1

INDEX TO CURVES

1 - BLACKSMITHS, GENERAL
2 - BRAKEMEN
3 - CARPENTERS
4 - CHANNEL RUNNERS
5 - DRILL "
6 - ELECTRICIANS
7 - LOCOMOTIVE CRANE OPERATORS

HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY, CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

WAGE RATES FOR VARIOUS CLASSES OF LABOUR AS PAID BY THE H.E.P.C.

Toronto, July 27th., 1923. Made by [illegible], Checked by [illegible]

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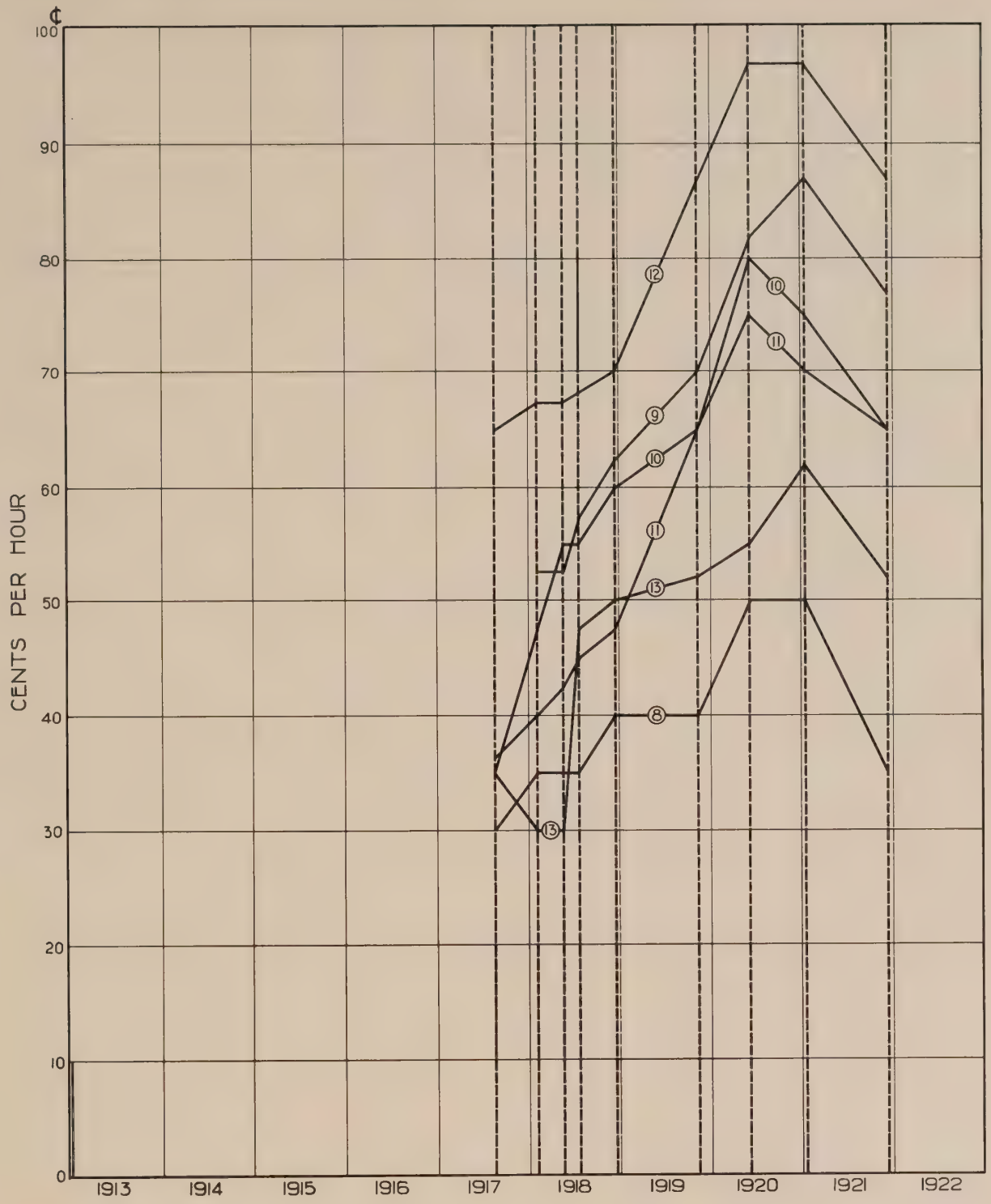

2

INDEX TO CURVES

8 - LABOURERS
9 - MACHINISTS
10 - PIPE FITTERS
11 - RIGGERS
12 - SHOVEL ENGINEMEN
13 - " FIREMEN

HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY, CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

WAGE RATES FOR VARIOUS CLASSES OF LABOUR AS PAID BY THE H.E.P.C.

Toronto, July 27th, 1923. Made by [illegible], Checked by [illegible]

WALTER J. FRANCIS & COMPANY

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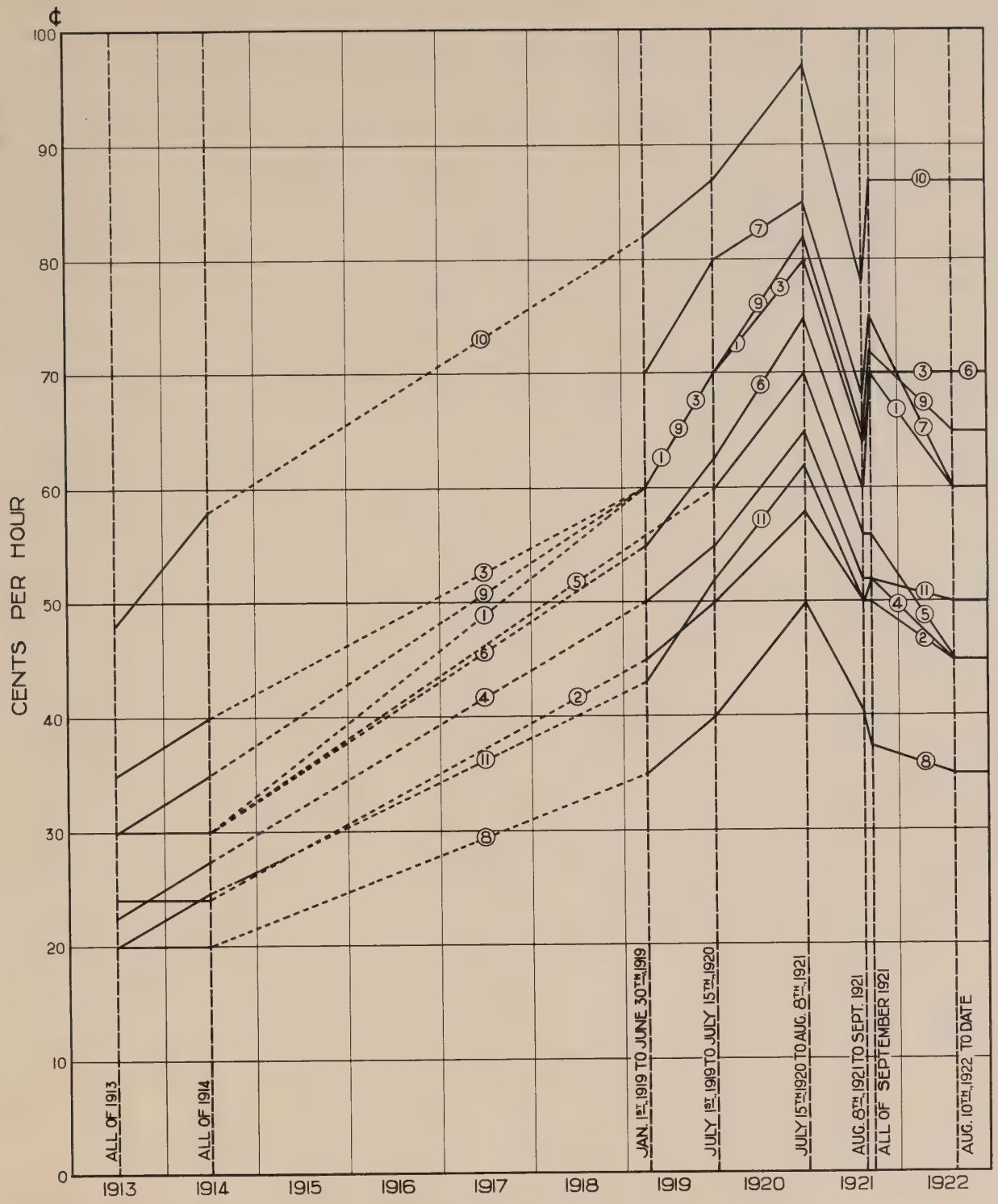

Note:- The Curves have been plotted from the following Data:-
Fair Wage Schedule 1913; Rates paid on Section 3, 1914; Rates Paid Jan. 1st to June 30th., 1919; Rates paid July 1st., 1919 to July 14th., 1920; Rates paid July 15th., 1920 to August 7th., 1921; Rates paid August 8th., 1921 to August 31st., 1921; Rates Paid September 1921 to August 9th., 1922; Rates paid August 10th., 1922 to February 1923.

INDEX TO CURVES

1 - BLACKSMITHS, GENERAL
2 - BRAKEMEN
3 - CARPENTERS
4 - DRILL RUNNERS, TRIPOD
5 - DRILL " , WELL
6 - ELECTRICIANS
7 - LOCOMOTIVE CRANE OPERATORS
8 - LABOURERS
9 - MACHINISTS
10 - STEAM SHOVEL ENGINEMEN
11 - STEAM " FIREMEN

HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
QUEENSTON-CHIPPAWA POWER DEVELOPMENT
WELLAND SHIP CANAL
DEPARTMENT OF RAILWAYS AND CANALS, CANADA
WAGE RATES FOR VARIOUS CLASSES OF LABOUR
Toronto, July 27th., 1923. Made by [illegible], Checked by [illegible]
WALTER J. FRANCIS & COMPANY
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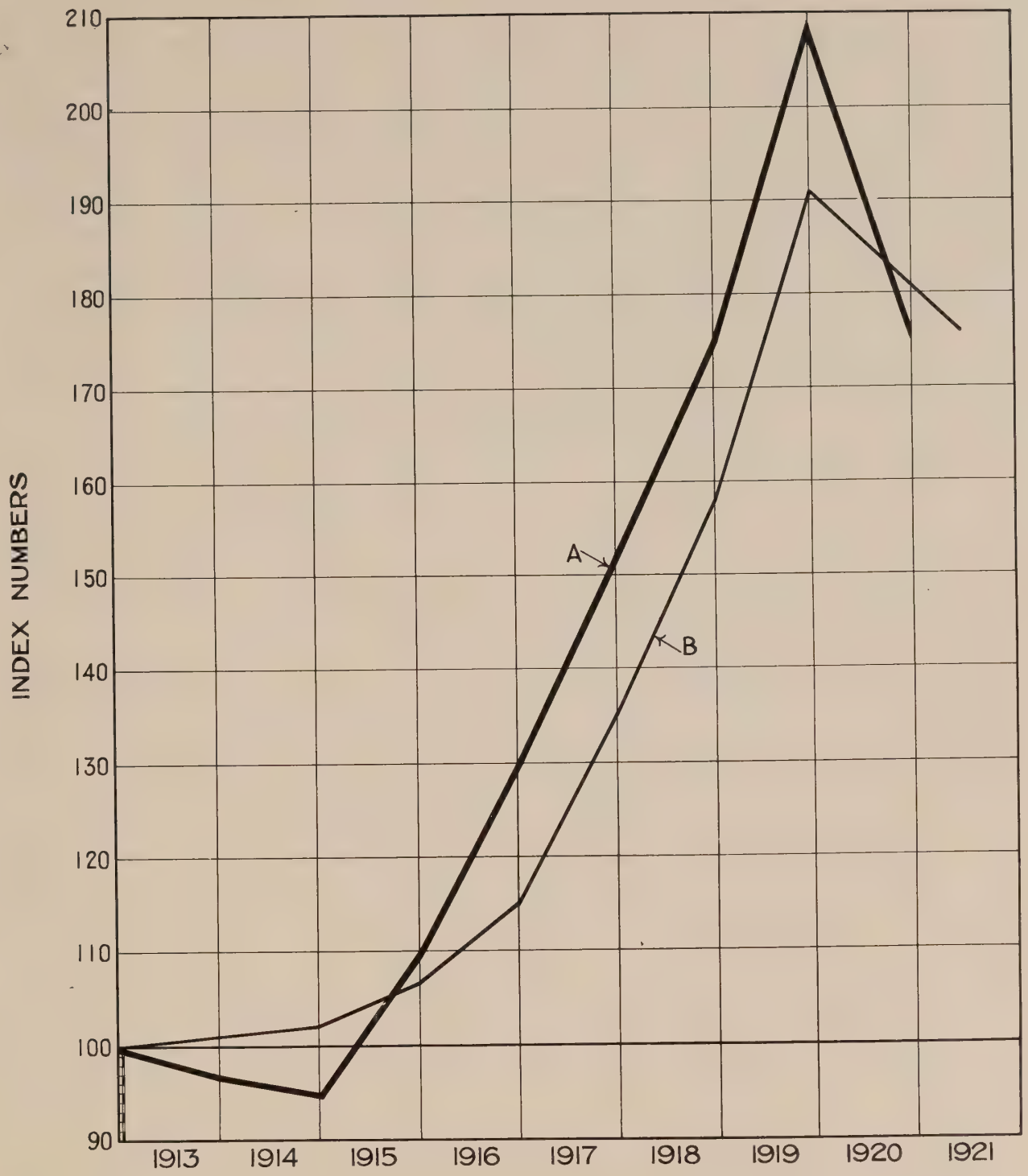


A - Common Labour; Based on Statistics of Common Labour in Factories and Camps.

B - Composite Curve giving Wage Rates for Twenty-one Classes from Thirteen Canadian Cities.

Note: Chart compiled from Report No 3, 1922, Department of Labour.

Hydro-Electric Inquiry Commission

W. D. Gregory, Chairman

Queenston-Chippawa Power Development

CURVES OF WAGE RATE INDEX NUMBERS BASED ON DEPARTMENT OF LABOUR

Toronto, July 27th, 1923. Made by G.E.B., Checked by L.J.H.

Walter J. Francis & Company

Consulting Engineers

close attention of a number of competent men for at least a year. We have, therefore, been compelled to deduce a result by shorter methods, and having done this we arrive at the estimated amount of wages paid as a result of inefficiency of labour compared with 1917 as $4,423,142.96. The curve representing this amount has also been plotted on the diagram on page M-3, already referred to, in a manner corresponding to the curve showing the total wages paid and the amount thereof due to the increase of wage rates.

Normal Wages Expenditure.

The area of the diagram on page M-3 below the curve representing inefficiency denotes the amount of the normal wages, being $8,530,219.20 out of the total of $19,896,657.53 paid up to December 31st, 1921.

Subsequent to this date there is no doubt that the efficiency of labour increased materially, and the amount paid in wages would approach more nearly normal, particularly as the wage rates then paid were declining.

General.

The three curves on page M-3 show clearly the disposition of the total amount paid for wages.

The amount of normal wages, $8,530,219.20, represents the amount of wages comparable with the 1917 estimates, or in other words the amount which would have been paid to the men who were actually employed had the wage rate and the efficiency remained the same as in 1917. This amount is for the work as constructed. In order to make it comparable with the estimates it is necessary

alone allowing of a method of comparison over the six years a year. In each, Blackburn, have succeeded in having a result by overtime methods, and having been this on brute at the estimated amount of wages paid as a result of inefficiency of labor compared with 1917 as $2,000,000,00. The entire recommendation of this report has also been stated on the diagram on page 8-4, already referred to. In a manner corresponding to the curve showing the total wages paid and the amount thereof due to the increase of wage rates.

Curve Under Discussion.

The line of the diagram on page 8-5 shows the entire proceedings in-cluding Bonus the amount of the bonus wages, being $2,000,000.00 and the total of $12,000,000.00 paid by to December 31st, 1918.

Happened to this note there is no doubt that the efficiency of labor increased materially, and the amount paid in wages which appeared were mainly earned, particularly as the wage rates than paid were doubling.

Comment.

The three curves on page 8-5 show clearly the disposition of the total amount paid for wages.

The amount of normal wages, $6,000,000.00, represents the amount at wages comparable with the 1917 estimates, or in other words the amount which have been paid in the new job were actually employed but the wage rate and the efficiency remained the same as in 1917. This amount is for the more or un-official. In order to make it comparable with the estimates it is necessary

to make a deduction, seeing that the work as constructed is greater than that estimated upon. Considering the additional quantities involved in the completed cost, this increase is about $10,900,000.00, and if a direct proportion be taken it will be seen that what might be called the normal wages expenditure for the estimated work will be on the order of $6,100,000.00.

In our studies it has been necessary to make a great number of calculations and curves, the inclusion of which would entail much study and would not help in the clearness of this discussion. It seems worth while, however, to include certain of the documents as the information they contain is of interest and value.

COPY

Labour Cost per Unit of Earth Excavation and Rock Excavation.

From the records of the Hydro-Electric Power Commission there has been deduced the labour cost per cubic yard of earth excavation and of rock excavation in the canal, exclusive of all other items in the cost of excavating, and these labour costs have been plotted on the diagram included herewith as M-10. From the curves on this diagram it will be seen that the labour cost for earth excavation which commenced early in 1917 remained practically constant for a year at 26 cents per cubic yard, rising fairly steadily until in September, 1921, it had reached about 70 cents per cubic yard.

In a somewhat similar way the labour cost of the rock excavation which commenced early in 1918 remained constant for about a year at 72 cents per cubic yard, rising more sharply than in the case of the earth excavation until it reached about $1.62 in September, 1921.

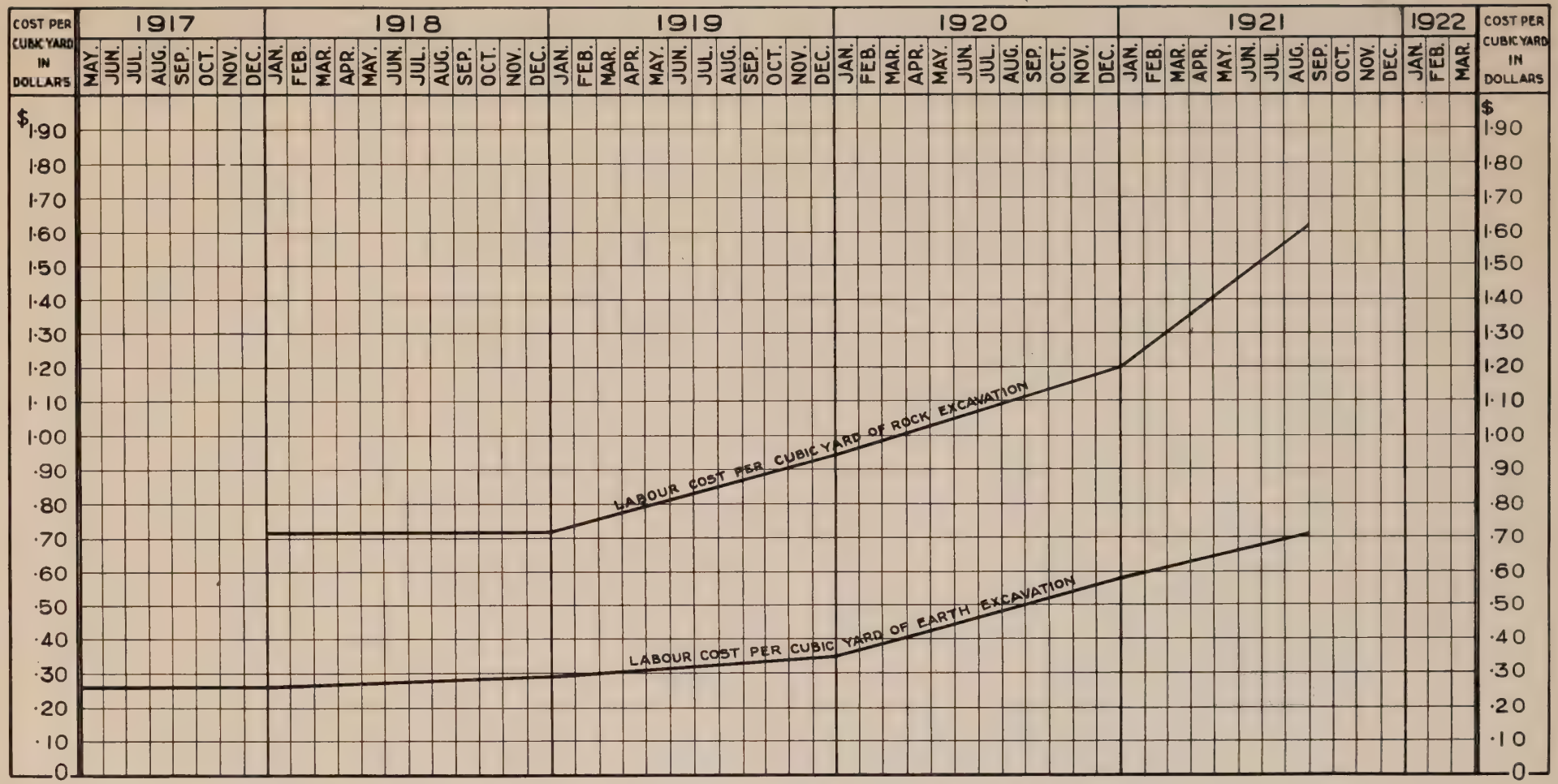
In order to determine, where that the work is maintained in proportion those that without risk. Furthermore the additional quantities required in the elementary work, this increase is about 20%-30%/month, and it a direct proportion to labour it will be seen that that right to relieve the normal water requirements for the estimated work will by on the order of 20.30%/month.

In our studies it has been necessary to make a rough method of calculation time and motion, the language of which would probably seem strange and unusual but in the circumstances of this discussion. It seems worth while, however, to include details of the assumptions as the information may prelude in of interest and value.

Labour Costs per Unit of Work Operation for Two Operations

From the records of the Superintendent Power Transmission Mains the team planned the labour cost per mile just of north connection and of each section in the model. Analysis of all other items in the cost of construction and these labour costs have been plotted in the diagram included between 2-10. From the curves in this diagram it will be seen that the labour cost for each construction which commenced early in 1917 remained practically constant for a time at 24 cents per mile pipe, minor fairly sharply until in September, 1921, it had reached about 91 cents per mile pipe.

It's suggested similar for the labour cost of the more successful sides commenced early in 1919 remained constant for about a year at 91 cents per mile pipe, rising more sharply than in the case of the earlier connections until it reached about 32.82 in September, 1921.



HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY, CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

LABOUR COST PER UNIT
EARTH EXCAVATION AND ROCK EXCAVATION

Toronto, July 27th, 1923. Made by [illegible], Checked by [illegible]

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(M-10)

It has been somewhat difficult to separate and analyze all these results, and to differentiate between the effect of the efficiency or inefficiency of labour and the effect of the efficiency or inefficiency of plant. We have found that in 1919 there appeared to be a combination of labour and machinery on the canal work which resulted in the lowest construction costs per unit of work. The inclusion, however, of other work, and the necessity of arriving at a result quickly renders it impossible to make a precise statement in this regard as to time and rate.

Number of Men Employed.

On page M-12 will be found a curve showing the number of men employed on the work in point of time. The curve has been plotted by taking the maximum number of men engaged on any one day during each month the work was in progress. This curve may be useful in a general way, but it proved to be of little value in analyzing the wages expenditure on account of the variation in time worked by each man. We therefore had to resort to the use of the "man-hour" unit, an expression denoting one hour of labour performed by one man.

Total Man-hours.

The curves shown on page M-13 indicate the total man-hours of labour entering into the work from the first of January, 1917, until the first of January, 1923. On the same page is plotted the total of the fortnightly payrolls for the same period.

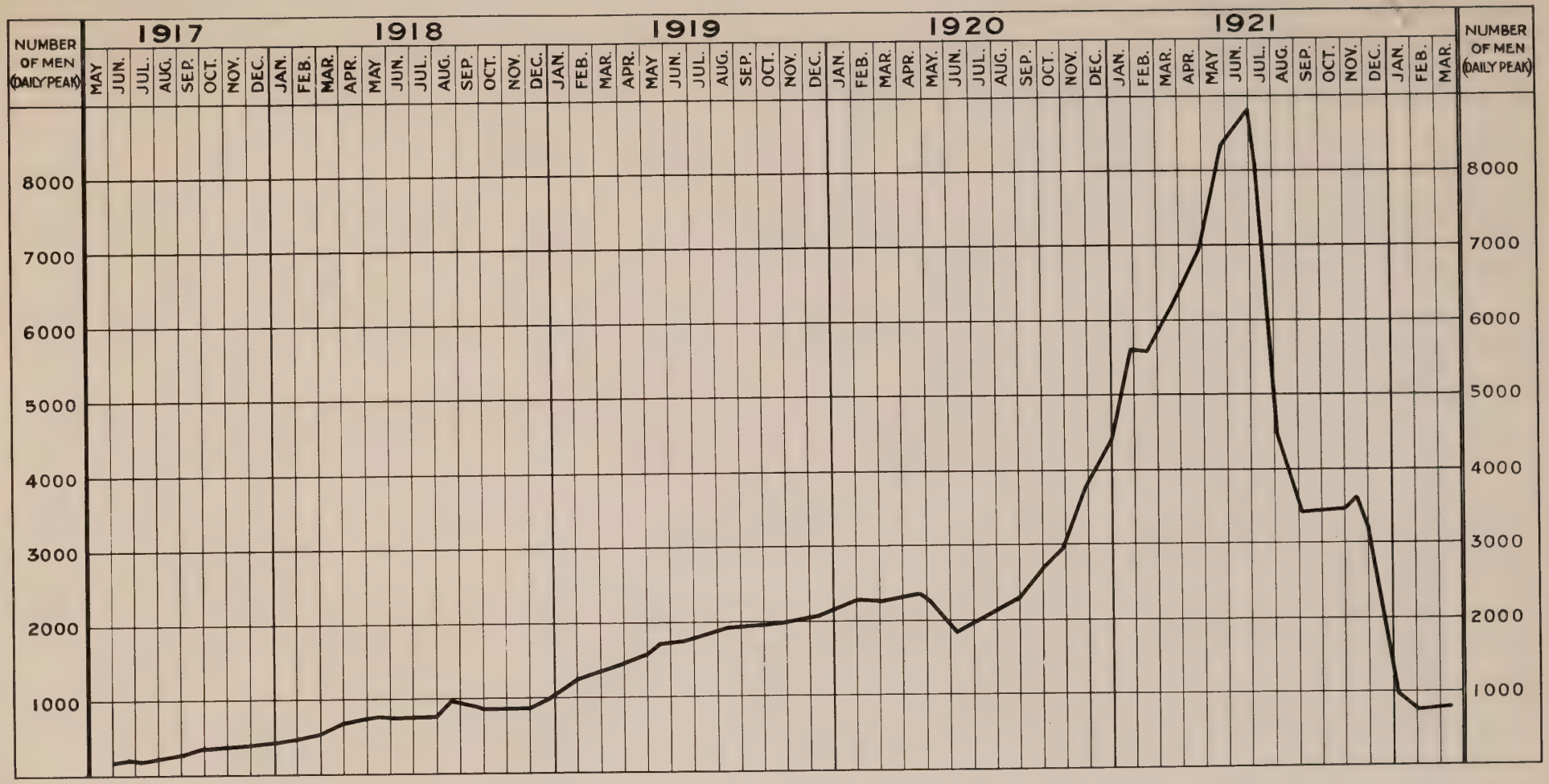
It has been remarked elsewhere in separate and detailed all Bowes results, and the differentials between the efforts of the efficiency by contribution of Sandor and his effect of the efficiency on contribution of Bowes. We have found that in 1919 Bowes appeared to be a combination of clayton and contribution on the usual work which resulted in the lower contribution were low work of work. The Contribution, however, of which work, was the commonly of activity in a month yearly problem if impossible to make a precise statement in this regard as to time and rate.

Number of the Imperial.

On page M-12 will be found a table showing the number of two machines as the were in point of time. The table has been plotted to show the machine number of each engaged on any one day for twenty hours. This table may be useful in a general way, but it proved of no little value in emphasizing the wide variations in amount of the variation in time worked in each row. In inspection that is nearly in the one of the "machine" work, an expression describing one hour of labor performed by one hour.

Total Non-Income.

The series shown on page M-13 indicate the total non-income of labor worker into the work from the first of January, 1917, until the first of January, 1920. On the same page is plotted the total of the operating profits for the same period.



Note:

The curve has been plotted by taking the maximum number of men engaged at one time during every month.

HYDRO-ELECTRIC INQUIRY COMMISSION

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QUEENSTON-CHIPPAWA POWER DEVELOPMENT

NUMBER OF MEN EMPLOYED (DAILY PEAK)

Toronto, July 27th, 1923. Made by [illegible], Checked by [illegible]

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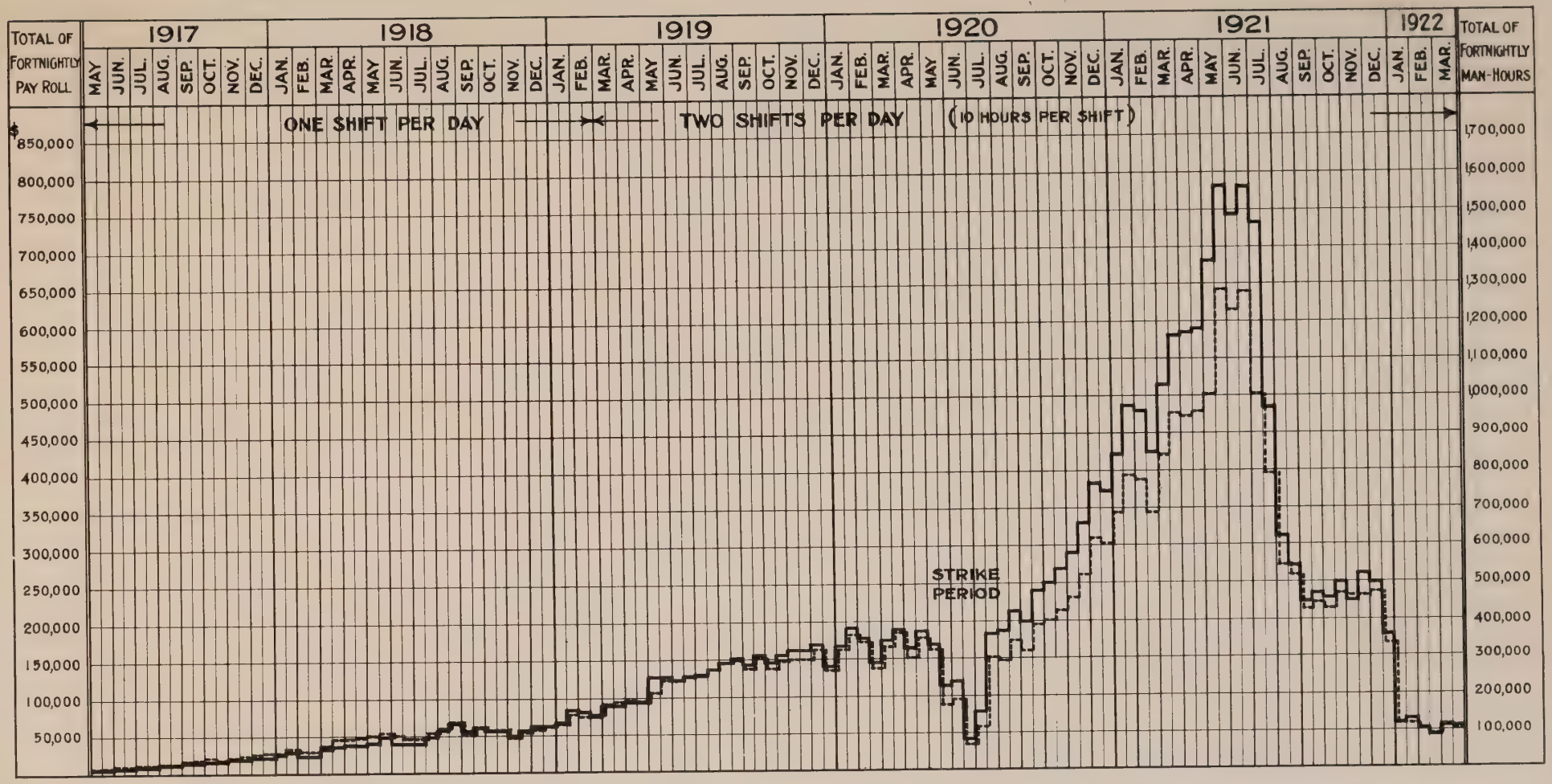
(M-12)



TOTAL AMOUNT OF THE FORTNIGHTLY PAY ROLLS IN DOLLARS ———

TOTAL MAN-HOURS FOR THE CORRESPONDING FORTNIGHTLY PAY ROLLS --------

HYDRO-ELECTRIC INQUIRY COMMISSION

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QUEENSTON-CHIPPAWA POWER DEVELOPMENT

TOTAL PAY ROLL AND TOTAL MAN-HOURS

Toronto, July 27th, 1923. Made by GEC Checked by WJF.

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(M-13)

Average Rate per Man-hour.

The average rate paid per man-hour on the work is shown in the diagram on page M-15. It will be seen that this average rate varies from about 36 cents per hour to about 64 cents per hour, which maximum obtained in July, 1920, and irregularly therefrom for about a year. This curve, indicating the average rate per man-hour, was obtained by dividing the total number of man-hours in each fortnight into the amount of the corresponding pay-roll. For the sake of convenience, the amount of each of the fortnightly pay-rolls is plotted on the same diagram. The average rate per man-hour was of considerable value in our computations, but as it depends upon the relative proportion of the various kinds of labour employed fortnight by fortnight it is difficult to apply.

Average Monthly Earnings per Man.

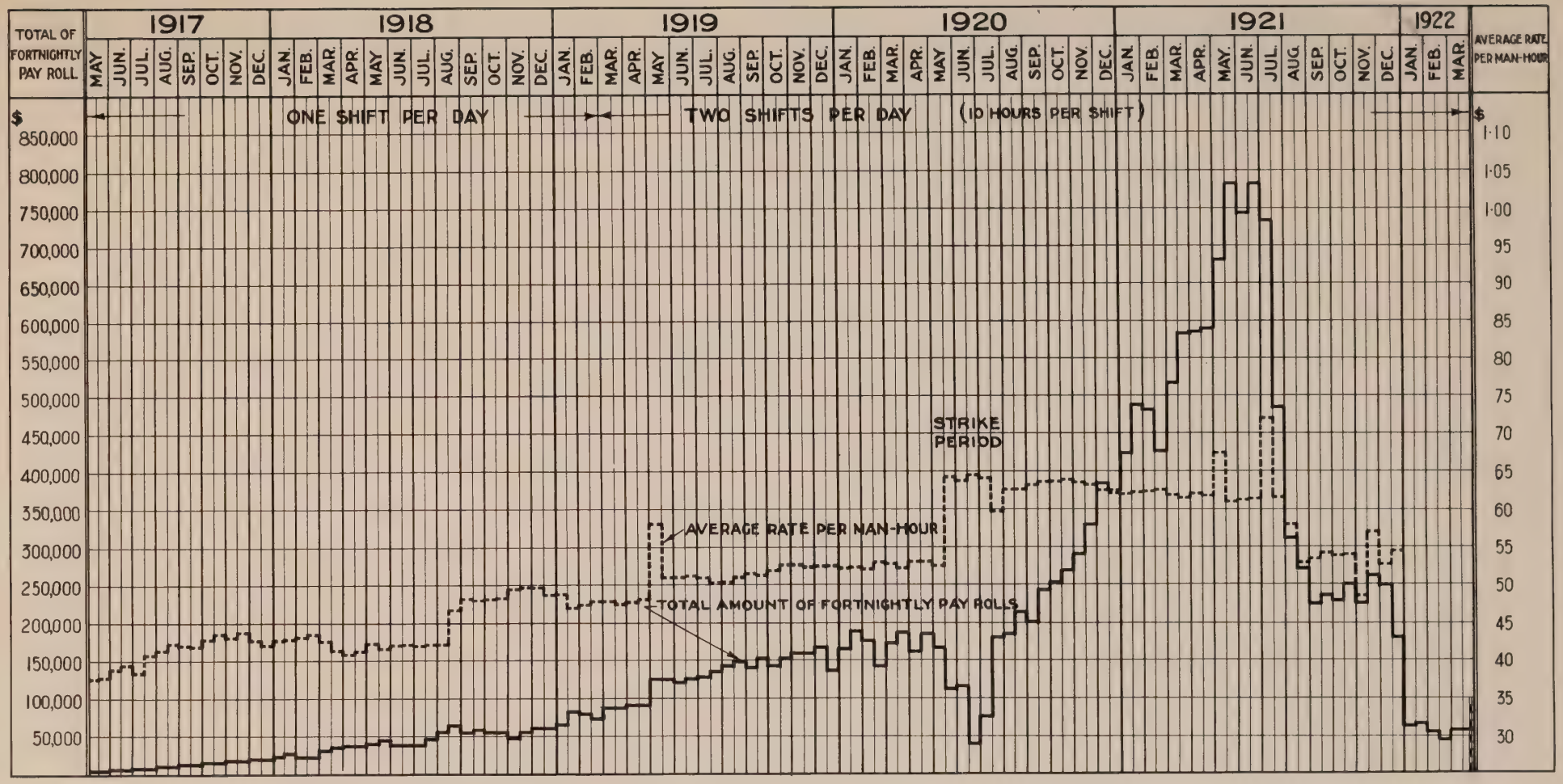
In pursuing the studies of the cost of the work, the Cost Department of the Hydro-Electric Power Commission has made a complete statement showing all the Fortnightly Periods from January 1st, 1917, to December 31st, 1921, together with the corresponding Pay-roll, the total Payment for the Month, the Average Daily Force and the Average Monthly Earnings per Man. The following is a transcription of this information:

Average Pole per Man-hour.

The average pole pole per man-hour on the work is shown in the diagram on page IE-138. It will be seen that this average was varied from time to time per hour to about 18 poles per hour, which maximum occurred in July, 1941, and irregularly throughout for about a year. This curve, indicating the average pole per man-hour, was obtained by dividing the total number of man-hours in each fortnight into the amount of the corresponding payroll. For the sake of convenience, the amount of work of the individually provided is plotted on the same diagram. The average pole per man-hour was of doubtful value in our computations, but was in agreement with the variation-graph of the various kinds of labour employed included by foreman; it is difficult to apply.

Average Daily Output per Man.

In planning the studies of the work of the shop, the first requirement of the Wyle-Lincoln Power Commission was such a complete statement showing all the Turbinelle Vessels from January 1st, 1937, to December 31st, 1941, in order with the corresponding pay-roll, the total tonnage for the month, the average daily tonnage and the average Monthly Earnings per Man. The following is a transcription of this information.



Note:

The curve marked "Average Rate per Man-Hour" is obtained by dividing the total number of man-hours into the amount of the corresponding pay roll.

HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY, CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

TOTAL PAY ROLL AND AVERAGE RATE PER MAN-HOUR

Toronto, July 27th, 1923. Made by [illegible], Checked by [illegible]

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CONSULTING ENGINEERS

(M-15)

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

1917		Amount of Pay-roll	Total for Month	Average Daily Force	Average Monthly Earnings per Man
		$	$		$
January	1-15	108.70			
	16-31	465.78	574.48	9	63.83
February	1-15	452.31			
	16-28	729.96	1,182.27	14	84.45
March	1-15	980.96			
	16-31	1,181.29	2,162.25	26	83.16
April	1-15	1,496.67			
	16-30	2,891.49	4,388.16	51	86.04
May	1-15	4,033.21			
	16-31	6,486.80	10,520.01	111	94.77
June	1-15	8,274.60			
	16-30	8,189.36	16,463.96	162	101.63
July	1-15	7,602.15			
	16-31	9,452.26	17,054.41	154	110.74
August	1-15	9,659.93			
	16-31	11,186.92	20,845.85	189	110.30
September	1-15	12,983.88			
	16-30	15,847.98	28,831.86	281	102.60
October	1-15	17,291.44			
	16-31	14,928.77	32,220.21	287	112.26
November	1-15	18,195.74			
	16-30	20,416.09	38,611.83	345	111.92
December	1-15	19,955.80			
	16-31	19,880.09	39,835.89	394	101.10

Terms of Labour - 10 hours a day with single time for overtime, Sundays and holidays.

1918		Amount of Pay-roll	Total for Month	Average Daily Force	Average Monthly Earnings per Man
		$	$		$
January	1-15	22,537.67			
	16-31	28,537.52	51,075.19	442	115.55
February	1-15	25,831.40			
	16-28	24,104.22	49,935.62	487	102.54
March	1-15	32,217.62			
	16-31	37,319.51	69,537.13	626	111.08
April	1-15	38,354.59			
	16-30	40,846.81	79,201.40	723	109.55
May	1-15	42,615.71			
	16-31	46,236.10	88,851.81	762	116.60

1917		Amount of Payroll	Total for Week	Average Daily Force	Average Weekly Wages per Man
		$	$		$
January	1-12	132.70			
	13-19	466.78	574.48	0	32.82
February	1-12	466.31			
	13-26	720.96	1,182.27	14	84.48
March	1-12	980.96			
	13-19	1,181.22	2,162.18	26	82.16
April	1-12	1,481.47			
	13-26	2,211.42	4,322.14	0	41.---
May	1-12	4,211.21			
	13-31	6,486.30	10,830.01	111	94.77
June	1-12	8,274.60			
	13-26	8,189.36	16,466.96	182	101.82
July	1-12	7,322.17			
	13-31	9,428.21	17,424.41	184	110.74
August	1-12	9,424.18			
	13-31	12,182.21	21,606.39	190	114.---
September	1-12	12,902.58			
	13-30	16,647.95	29,551.66	281	103.80
October	1-12	17,291.44			
	13-31	14,938.77	32,230.21	287	112.85
November	1-12	16,192.74			
	13-30	20,411.[illegible]	36,[illegible].23	341	114.---
December	1-12	19,936.89			
	13-31	19,880.09	39,816.89	364	109.10

Terms of labor - 12 hours a day with single line for overtime, Sundays and holidays.

1918		Amount of Payroll	Total for Week	Average Daily Force	Average Weekly Wages per Man
		$	$		$
January	1-12	22,127.47			
	13-31	28,837.82	50,075.19	441	113.47
February	1-12	22,212.[illegible]			
	13-28	24,192.22	46,[illegible].42	427	108.---
March	1-12	32,317.62			
	13-31	37,219.21	69,537.13	455	121.47
April	1-12	38,554.82			
	13-30	41,[illegible].21	79,[illegible].42	712	1[illegible].---
May	1-12	42,212.71			
	13-31	44,[illegible].13	86,[illegible].81	721	114.---

1918		Amount of Pay-roll	Total for Month	Average Daily Force	Average Monthly Earnings per Man
		$	$		$
June	1-15	42,407.38			
	16-30	40,429.69	82,837.07	758	109.28
July	1-15	40,702.00			
	16-31	47,494.57	88,196.57	751	117.44
August	1-15	55,583.68			
	16-31	63,843.50	119,427.18	869	137.43
September	1-15	52,134.64			
	16-30	59,005.27	111,139.91	913	121.73
October	1-15	55,830.72			
	16-31	56,200.15	112,030.87	832	134.65
November	1-15	47,883.52			
	16-30	55,579.23	103,462.75	817	126.63
December	1-15	58,087.14			
	16-31	61,971.02	120,058.16	989	121.39

Terms of labour - 10 hours a day with single time for overtime, Sundays and holidays.

1919		Amount of Pay-roll	Total for Month	Average Daily Force	Average Monthly Earnings per Man
		$	$		$
January	1-15	64,683.07			
	16-31	83,435.43	148,118.50	1,118	132.49
February	1-15	81,895.20			
	16-28	72,801.50	154,696.70	1,309	118.18
March	1-15	87,665.17			
	16-31	90,854.02	178,519.19	1,405	127.06
April	1-15	93,882.12			
	16-30	91,399.41	185,281.53	1,446	128.13
May	1-15	123,657.34			
	16-31	125,687.64	249,344.98	1,610	154.87
June	1-15	122,878.17			
	16-30	129,409.85	252,288.02	1,704	148.06
July	1-15	127,770.55			
	16-31	137,445.27	265,215.82	1,852	143.20
August	1-15	144,198.59			
	16-31	151,891.86	296,090.45	1,923	153.97
September	1-15	141,443.28			
	16-30	155,224.69	296,667.97	1,953	151.90
October	1-15	142,725.44			
	16-31	154,385.01	297,110.45	1,921	154.66

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		$	$	$
[illegible]	1-15	[illegible]		
	16-30	[illegible]	[illegible]	[illegible]
[illegible]	1-15	[illegible]		
	16-31	[illegible]	[illegible]	[illegible]
August	1-15	[illegible]		
	16-31	[illegible]	[illegible]	[illegible]
September	1-15	[illegible]		
	16-30	[illegible]	[illegible]	[illegible]
October	1-15	[illegible]		
	16-31	[illegible]	[illegible]	[illegible]
November	1-15	[illegible]		
	16-30	[illegible]	[illegible]	[illegible]
December	1-15	[illegible]		
	16-31	[illegible]	[illegible]	[illegible]

Sums and labour - 15 [illegible] [illegible] [illegible]

1919		Amount of Pay-roll	Total for Month	Average Daily Force	Average Monthly Earnings per Man
		$	$		$
November	1-15	160,581.38			
	16-30	159,289.41	319,870.79	2,053	155.80
December	1-15	170,394.97			
	16-31	140,816.36	311,211.33	2,073	150.13

Terms of labour - 10 hours a day with single time for overtime, Sundays and holidays to the end of April. Commencing in May - 8 hours a day with double time for Sundays and holidays; time and a half for overtime. (10 hours constitutes a regular working day.)

1920		Amount of Pay-roll	Total for Month	Average Daily Force	Average Monthly Earnings per Man
		$	$		$
January	1-15	168,710.52			
	16-31	191,013.28	359,723.80	2,545	141.35
February	1-15	179,073.04			
	16-29	145,197.27	324,270.31	2,515	128.88
March	1-15	174,867.70			
	16-31	190,878.95	365,746.65	2,537	144.16
April	1-15	163,741.26			
	16-30	187,062.31	350,803.57	2,534	138.44
May	1-15	168,152.88			
	16-31	114,337.91	282,490.79	2,505	112.77
June	1-15	119,315.19			
	16-30	41,466.32	160,781.51	1,266	127.00
July	1-15	75,424.00			
	16-31	183,552.06	258,976.06	1,841	140.67
August	1-15	185,987.03			
	16-31	216,903.67	402,890.70	2,797	144.04
September	1-15	201,569.01			
	16-30	247,681.15	449,250.16	3,012	149.15
October	1-15	256,009.99			
	16-31	271,080.39	527,090.38	3,561	148.02
November	1-15	292,788.39			
	16-30	330,074.19	622,862.58	4,088	152.36
December	1-15	385,810.41			
	16-31	375,287.03	761,097.44	5,402	140.89

Terms of labour - 8 hours a day with double time for Sundays and holidays. Time and a half for overtime

Date	Amount of Check	Value Per Check	Cumulative Total Value	Average Cumulative Amount
		$		$
January 1-15	[illegible]			
16-30	120,[illegible]	312,[illegible].79	2,[illegible]	106.00
February 1-15	170,[illegible]	[illegible]	[illegible]	[illegible]
16-28	[illegible]	[illegible]	[illegible]	[illegible]

Total of Jobs - 37 Boats a day (Only the 15-day periods.
Sundays and holidays to the end of April.
Commission is 5% - 5 boats a day with the 15th Sunday
plus the Monday and holidays. The end of April
the average. (If boats average a regular
working day.)

Date	Amount of Check	Value Per Check	Cumulative Total Value	Average Cumulative Amount
		$		$
January 1-15	[illegible]			
16-31	[illegible]	[illegible]	2,[illegible]	[illegible]
February 1-15	[illegible]			
16-29	[illegible]	[illegible]	4,[illegible]	[illegible]
March 1-15	[illegible]			
16-31	190,[illegible]	888,[illegible].55	8,[illegible]	244.16
April 1-15	[illegible]			
16-30	187,[illegible]	380,[illegible].87	8,[illegible]	180.44
May 1-15	[illegible]			
16-31	[illegible]	[illegible]	[illegible]	[illegible]
June 1-15	[illegible]			
16-30	[illegible]	180,[illegible].83	1,[illegible]	147.05
July 1-15	[illegible]			
16-31	188,[illegible].06	260,[illegible].06	1,[illegible]	140.87
August 1-15	[illegible]			
16-31	[illegible]	[illegible]	[illegible]	[illegible]
September 1-15	[illegible]			
16-30	[illegible]	[illegible]	[illegible]	[illegible]
October 1-15	[illegible]			
16-31	[illegible]	[illegible]	[illegible]	[illegible]
November 1-15	[illegible]			
16-30	[illegible]	[illegible]	[illegible]	[illegible]
December 1-15	[illegible]			
16-31	370,[illegible].08	763,[illegible].44	8,[illegible]	140.34

Total for Jobs - 4 boats a day - [illegible] Sundays
and holidays. Then add a half for overtime.

until May 14th. (10 hours constitutes a regular working day.) 8 hours a day with straight time for Sundays and holidays, and no overtime May 14th to June 15th. 10 hours a day with time and a half for Sundays, holidays and overtime.

1921		Amount of Pay-roll	Total for Month	Average Daily Force	Average Monthly Earnings per Man
		$	$		$
January	1-15	424,871.34			
	16-31	490,602.24	915,473.58	5,580	164.06
February	1-15	483,095.18			
	16-28	428,038.77	911,133.95	5,298	171.98
March	1-15	521,168.11			
	16-31	585,547.52	1,106,715.63	6,198	178.56
April	1-15	585,221.69			
	16-30	590,942.78	1,176,164.47	6,917	170.04
May	1-15	681,805.43			
	16-31	784,094.81	1,465,900.24	8,299	176.64
June	1-15	745,394.24			
	16-30	785,504.91	1,530,899.15	8,666	176.65
July	1-15	738,115.50			
	16-31	487,468.14	1,225,583.64	7,165	171.05
August	1-15	312,058.84			
	16-31	271,933.46	583,992.30	3,793	153.96
September	1-15	227,337.50			
	16-30	240,099.78	467,437.28	3,344	139.79
October	1-15	229,797.53			
	16-31	252,525.36	482,322.89	3,325	145.06
November	1-15	227,044.26			
	16-30	264,842.80	491,887.06	3,496	140.70
December	1-15	250,565.07			
	16-31	179,737.75	430,302.82	2,749	156.53

Terms of labour - 10 hours a day with time and a half for Sundays, holidays and overtime.

From the above tables the earnings of the men year by year were derived, and found to be as follows:

Total Yearly Earnings of the Men

1917	-	$ 212,691.18
1918	-	1,075,753.66
1919	-	2,954,415.73
1920	-	4,865,983.95
1921	-	10,787,813.01
Total earnings	-	$19,896,657.53

From the above figures the average monthly earnings per man for the year are seen to be:

1917	-	$ 96.90
1918	-	118.65
1919	-	143.20
1920	-	138.98
1921	-	161.08

The rise in percentage over and above the average monthly earnings in 1917 per man per year is 22 per cent. for 1918, 48 per cent. for 1919, 43 per cent. for 1920 and 67 per cent. for 1921.

A Study of the Estimated Cost of the Queenston-Chippawa Power Development.

We have made a study of the estimated cost of the Queenston-Chippawa Power Development in relation to the cost of the work as constructed and about to be completed, using a six-unit plant in both cases.

Estimate No. 2.

The following is a transcription of Estimate No. 2 of November 27th, 1917:

Items	Estimate No. 2 (See Chapter X - Costs, Appendix III) Quantities	Unit Costs	Total Dollars
Intake			
Cofferdams	1,980 lin.ft.	$100.00	$198,000
Pumping	-	-	50,000
Excavation	427,000 cu.yds.	.60	256,200
Concrete	46,900 cu.yds.	8.00	375,000
Reinforcing steel	626,000 lbs.	.05	31,300
Steel plate	57,600 lbs.	.10	5,760
Lighthouse	1	-	8,000
Sluice-gate	1	-	10,000
Ship channel gates	-	-	30,000
Piling	13,250 lin.ft.	.35	4,640
Lumber	80,000 ft.b.m.	.06	4,800
		Total for Intake	$973,700
Welland River			
Dredging	2,504,000 cu.yds.	$ .20	$500,800
Rip-rap	17,600 cu.yds.	1.50	26,400
Concrete	700 cu.yds.	8.00	5,600
Reinforcing steel	11,700 lbs.	.05	584
		Total for Welland River	$533,384
Canal			
Dredging	282,000 cu.yds.	$ .20	$ 56,400
Earth excavation	8,936,450 cu.yds.	.27	2,412,842
Rock excavation	3,154,350 cu.yds.	.98	3,091,290
Concrete, plain	44,398 cu.yds.	6.50	288,587
Concrete, plain and reinforced	24,920 cu.yds.	8.00	199,360
Concrete, reinforced	87,570 cu.yds.	10.00	875,700
Concrete, special	11,395 cu.yds.	12.00	136,740
Rip-rap	188,640 cu.yds.	1.50	282,960
Structural steel and gates	2	15,000.00	30,000
Superstructure for gates	144,000 cu.ft.	.122	17,589
Piling	20,000 lin.ft.	.35	7,000
Reinforcing steel	4,269,400 lbs.	.05	213,470
		Total for Canal	$7,611,938

Items	Estimate No. 2 (See Chapter K - Costs, Appendix III) Quantities	Unit Costs	Total Dollars
Forebay			
Earth excavation	22,700 cu.yds.	$ .27	$ 6,129
Rock excavation	349,500 cu.yds.	.98	342,510
Concrete, plain	5,950 cu.yds.	6.50	38,675
Concrete, plain and reinforced	970 cu.yds.	8.00	7,760
Rip-rap	2,800 cu.yds.	1.50	4,200
Reinforcing steel	12,000 lbs.	.05	600
		Total for Forebay	$399,874
Bridges			
Highway	-	-	$293,203
Railway	-	-	317,120
		Total for Bridges	$610,323
Right-of-way		Total for Right-of-way	$600,000
Gate and Screen House			
Rock excavation	23,500 cu.yds.	$ .98	$ 23,030
Concrete, reinforced ...	3,000 cu.yds.	12.00	36,000
Concrete, plain	10,000 cu.yds.	8.00	80,000
Reinforcing steel	320,000 lbs.	.05	16,000
Structural steel and racks	402,000 lbs.	.07	28,140
Concrete in ice chute ..	965 cu.yds.	6.50	6,275
Steelwork in ice chute .	164,000 lbs.	.05	8,200
Gates	6	10,000.00	60,000
Superstructure	687,100 cu.ft.	.15	103,063
		Total for Gate and Screen House	$360,708
Penstocks			
Tunnel excavation	3,760 cu.yds.	$ 6.00	$ 22,560
Rock excavation	11,500 cu.yds.	2.25	25,876
Steelwork	4,365,000 lbs.	.07	305,550
Concrete	8,500 cu.yds.	6.50	55,250
		Total for Penstocks	$409,236

Items	Estimate No. 2 (See Chapter K - Costs, Appendix III) Quantities	Unit Costs	Total Dollars
Power House			
Unwatering	-	.... $ - ..	$ 50,000
Talus excavation	219,500 cu.yds.	.... 1.00 ..	219,500
Rock excavation	104,900 cu.yds.	.... 1.50 ..	157,350
Concrete in substructure	66,000 cu.yds.	.... 8.00 ..	528,000
Reinforcing steel	300,000 lbs.	.... .05 ..	15,000
Superstructure	4,602,000 cu.ft.	.... .15 ..	690,300
		Total for Power House ..	$1,660,150
Power House Machinery and Equipment			
Main turbines and governors	6 main units	....$270,000.00	$1,620,000
Exciter turbines and governors	2 units	.... 24,000.00	48,000
Auxiliary hydraulic equipment	-	-	100,000
Electrical equipment	6 main units	... 400,000.00	2,400,000
Auxiliary electrical equipment	-	... -	850,000
		Total for Power House Machinery and Equipment ..	$5,018,000
Miscellaneous			
Service tunnel	-	... - ..	$ 75,000
Sundries	-	... - ..	100,000
		Total for Miscellaneous Items ..	$ 175,000
		Total of above items ..	$18,352,313
Engineering, contingencies and so forth, 25 per cent.			4,588,078
Interest during construction 7½ per cent.			1,375,424
		Total Estimated Cost	$24,316,815

The table below shows a summary comparison between Estimate No. 2 and an estimate for a plant with six complete generating units as now being built. The latter figures are based on the "Analysis of Expenditure

to March 31st, 1922 - Chapter K - Costs", supplemented by estimates of the amounts required to complete the plant for six units, which estimates have been discussed with and generally approved by the engineers of the Hydro-Electric Power Commission within the past few weeks.

Comparison of Estimate No. 2 with 6-Unit Plant as Built

Items	Estimate No. 2 (See Chapter K - Costs, Appendix III) Estimated Cost - Dollars	Plant as built - Complete for Six Units Estimated Cost - Dollars
Intake	$ 973,700	$ 2,500,000
Welland River	533,384	1,500,000
Canal	7,611,938	36,500,000
Forebay	[illegible]	1,250,000
Screen and Gate House	760,708	1,750,000
Bridges	610,323	2,650,000
Right-of-way	600,000	1,000,000
Penstocks	409,239	1,250,000
Power House	1,660,150	3,500,000
Power House Machinery and Equipment	5,018,000	6,500,000
Miscellaneous	175,000	150,000
	$18,352,313	$58,550,000
Engineering, Contingencies, Administration and so forth	4,588,078	-
Interest during Construction	1,376,424	4,750,000
	$24,316,815	$63,300,000
Power House Railway		200,000
Plant Salvage		3,000,000
Stores		1,650,000
Expenses of Plant Salvage		110,000
Miscellaneous Sales and Work Orders		60,000
Suspense Account		5,000
Total		$68,325,000
Credit Plant, Stores Account, and so forth, say		4,000,000
Net total cost of Six-unit Plant as constructed		$64,325,000
Net total, Estimate No. 2		24,316,815
Difference between Estimate No. 2 and Estimated Cost as Built		$40,008,185

In March 1941 - Chapter 2 - 1939", explained by witness at the [illegible] provided on complete the plans for [illegible], which [illegible] been discussed with and generally approved by the engineers in the Ministry Supply Executive - which [illegible] the [illegible].

Comparison of Estimate No. 2 with Actual Cost as Built

Items	Estimate No. 2 (See Chapter 2 - 1939, Appendix (2)) Estimated Cost - Dollars	Cost as Built - Completed Per Its Cards Actual Cost - Dollars
Labour	[illegible]	[illegible]
Railway Siding Labour	[illegible]	[illegible]
Coal	[illegible]	[illegible]
Turbine	[illegible]	[illegible]
Turbine and Gear Boxes	[illegible]	[illegible]
Boilers	[illegible]	[illegible]
Boiler Feed Pumps	[illegible]	[illegible]
Air-Cooler	600,000	[illegible]
Transformer	[illegible]	[illegible]
Power Piping	1,660,180	[illegible]
Power Piping Machinery and Equipment	[illegible]	[illegible]
Electrical Equipment	[illegible]	[illegible]
Plumbing, Ventilation, Electrical Equipment and Up-Draft Ventilation Equipment	[illegible]	[illegible]
Structural Steel	[illegible]	[illegible]
Power House Building	[illegible]	[illegible]
Plant Railway	[illegible]	[illegible]
Stores	[illegible]	[illegible]
Expenses of Plant Erection	[illegible]	[illegible]
Miscellaneous Sales and Work Orders	[illegible]	[illegible]
Business Income	[illegible]	[illegible]
Total	[illegible]	[illegible]
Credit Plant, Stores Inventory, and Sales, Any material for Total Cost of Plant Total as Constructed	[illegible]	[illegible]
Net Total, Column No. 2	[illegible]	[illegible]
Difference between Estimate No. 2 and Estimated Cost as Built	[illegible]	[illegible]

Variations from Estimate No. 2.

The main differences between Estimate No. 2 and the plant as being built and completed in 1923 for six units are described below.

The total difference in cost of approximately $40,000,000 to be accounted for as between Estimate No. 2 and the plant as being constructed, both on the six-unit basis, may be summarized briefly as follows: The original Estimate No. 2 was for a canal having a nominal capacity of 10,000 cubic feet of water per second with an intake of the ordinary type, and the whole design was based on an ultimate installation of six main generating units with a nominal capacity of 50,000 horse-power each while the plant as built is designed for a nominal capacity in the Canal of 15,000 cubic feet of water per second. The Canal as built has a type of intake different from that originally contemplated, and the whole design is based on an ultimate installation of nine or ten main generating units with a nominal capacity of 55,000 horse-power each. In considering the differences between the plant contemplated in Estimate No. 2 and the six-unit plant as built it may be well to emphasize the fact that Estimate No. 2 is based on a design proportioned to utilize 10,000 cubic feet of water per second throughout, while the various elements of the plant as built are all proportioned for a nominal flow of 15,000 cubic feet of water per second, being 50 per cent. greater capacity than the former design. The changed design involved largely increased quantities of many of the principal items of construction. An analysis of the main features of the work shows the following:

Intake. The original design was for the usual pier and boom type of

Deviation from Palmer's Ex. 2.

The main difference between Palmer's Ex. 2 and the plant as being built and supplied in 1928 for its owners was described below.

The total difference is that at approximately 6ft.,4in.,2ft. as is customary for an enclosed Particular Ex. 2 had the plant in a large compartment, with on the air-cell basis, and by combined twisting as follows. The original in Ex. 2 was for a small cotton ginning plant, or 4,000 bales per year of white per return with an change of the particular type, and the whole design was based on an estimate installation of air cell particular with a combined separate or light or heavy or mixed per annum. The Ex. 2 is equally in the final or light quite that of mixed per annum. The Ex. 2 is with the 3 type of lines different from that originally submitted, and the whole design is based on an actual installation of size or the main machinery units with a normal capacity of 30,000 lbs/per-hour each. In consideration the difference between the plant manufactured in Victoria Ex. 2 and the original plant as built it may be well to explain the fact that Particular Ex. 2 is based on a design prepared to utilize 4,000 bales per of cotton per annum, which is the main machinery, while the original commence of the plant as built was all proportioned for a normal rate of 4,000 bales that or bales per annum. Being 30 per cent greater capacity than the Ex. 2 design. The changed design involved considerable of some of the physical laws of construction. In addition of the main Pressure of the very large the Difficulty.

Lining. - The original design was for the usual plain one type of

intake, while the structure as built was specially designed after exhaustive study, with provision for gathering tubes extending out into the river if the experience of operation prove them necessary. It is stated by Mr. Gaby in a letter of January 29th, 1923, that the adopted design involved an increased estimated expenditure of $1,922,720 over that provided for in Estimate No. 2, making the total estimated cost about $3,000,000.

The gathering tubes are not yet installed, but they may be required for the ultimate development. A reasonable allowance for the intake construction for the six-unit plant may be placed at $2,500,000, omitting the extensions of the gathering tubes.

Welland River. The original design provided for earth dredging in the Welland River to the amount of about 2,500,000 cubic yards at 20 cents per cubic yard. The construction records show that at March 31st, 1922, about 1,200,000 cubic yards were removed at a cost of about 75 cents per cubic yard. Subsequent contracts for additional dredging have been let at 33 cents per cubic yard. It therefore appears reasonable to place the cost of earth dredging in the Welland River for six units at about $1,500,000, but the quantities in the completed six-unit plant will be about the same as used in Estimate No. 2.

Canal. Originally it was estimated that the earth dredging in the Canal would amount to about 282,000 cubic yards at 20 cents per cubic yard. At March 31st, 1922, over 1,250,000 cubic yards had been removed at an average cost of about 76 cents per cubic yard. A comparatively small additional amount of earth dredging is required to complete the Canal for six units. It

therefore seems reasonable to allow for 1,000,000 cubic yards of earth dredging in addition to that used in Estimate No. 2.

The original estimate for earth excavation in the Canal has been exceeded by over 1,300,000 cubic yards, and the rock excavation in the Canal has been similarly increased by nearly 750,000 cubic yards as compared with Estimate No. 2.

Concrete of all classes was originally estimated at 168,283 cubic yards at an average cost of $8.80 per cubic yard. The concrete in the construction amounted to 304,299 cubic yards as at March 31st, 1922, being an increase of about 136,000 cubic yards of special concrete. Probably 140,000 cubic yards is a fair allowance for the total additional concrete in the Canal, all of the class provided for in Estimate No. 2 at the highest unit price.

Rip-rap was originally estimated at 188,640 cubic yards. At March 31st, 1922, 986,028 cubic yards of rip-rap had been placed, making a total of about 800,000 cubic yards of rip-rap over and above the estimated quantity.

The reinforcing steel placed in the work was much in excess of the quantity used in the Estimate.

The records show that about $1,800,000 has been expended over the whole Development for unwatering, the greater part of which was directly concerned with the Canal. Unwatering was originally estimated upon as part of the unit costs used for computing the cost of the earth and rock excavation. Provision was apparently made for the usual pumping and baling of a canal designed at a

Unwalkers rooms reconsidered to allow for 1,000,000 cubic yards of earth excavation in addition to that used in Estimate No. 2.

The original estimate for earth-excavation in the dam was very considerably in excess of 1,000,000 cubic yards, and for rock excavation in the front dam was significantly increased to nearly 700,000 cubic yards as compared with Estimate No. 2.

Towards the end of 1922 the cost was finally estimated at 16,000,000 cubic yards as an average cost of $0.61 per cubic yard. The increase in the estimated quantities to 800,000 cubic yards, as at March 31st, 1922, being an increase of about 114,000 cubic yards in the rock excavation. Probably 114,000 cubic yards is a fair allowance for the total additional quantity in the dam, all of the place provided for in Estimate No. 2 at the highest cost price.

Air-drop was originally estimated at 224,000 cubic yards. At March 31st, 1922, 224,000 cubic yards of air-drop had been cleared, making a total of about 300,000 cubic yards of air-drop that had more than the estimated quantity.

The retaining steel placed in the dam was such as to make it the quantity used in the Estimate.

The concrete also had cost over $1,000,000 the then expected over the whole development for construction, the greater part of which was directly connected with the dam. Considering the difficulty estimated upon as part of the dam work and the complicated the cost of the work had been considerable. Therefore was necessarily made for the steel erection and delivery of a small carriage of a

higher level than that which was made and draining generally by gravity towards Bowman's Gully. In Estimate No. 2 there is no special item for canal unwatering. The elevation of the floor of the Canal as built is lower than that of the canal considered in Estimate No. 2 by several feet, the general difference being three feet. The records show that it was impracticable to follow the original ideas for drainage to Bowman's Gully. When the ground had been opened up during construction numerous large springs were exposed, the flow of which required continuous pumping. The daily pumpage frequently amounted to 20,000,000 gallons of water, and an aggregate installed pumping capacity of about 30,000,000 gallons per day had to be kept available.

Forebay. In the Forebay, Estimate No. 2 provided for 349,500 cubic yards of rock excavation, while the amount of rock removed was about 125,000 cubic yards more than the estimated amount.

Screen House. The Screen House contains greater quantities of work than were contemplated in Estimate No. 2. The rock excavation work was increased by over 20,000 cubic yards, and the concrete work was increased by about 16,000 cubic yards.

Power House. The rock excavation work in the Power House is about 75,000 cubic yards more than that provided for in Estimate No. 2.

The concrete in the Power House is of a more costly type than that used in Estimate No. 2, due to the development of the Moody spreading draft tube design subsequent to the time when Estimate No. 2 was prepared. The superstructure as built is larger than that figured in Estimate No. 2, and improvements have been

Higher level than that which was made and involving personally by nearly seventy Department's staff. In Berkeley the 2 Ships is an minimal line for usual structure. The elevation of the floor of the Bend we built is lower than that of the world established in Kingsville Pa. by natural road, the Lincoln Highway being lower level. The results show that it was impossible to obtain the initial lines for building in Bensonhurst Bailey. Some are given the most special of trying construction involves large surface work requires, but also of which typical contract problem. The daily progress for certain excavation is 20,000 gallons of water, and an experienced labor working excavating a about 20,000,000 yd/ft per day had to be that necessitate.

COPY

Question. In the Pittsburgh district we are operating the 110,000 cubic yd. of some excavation well. The amount of rock removed was other 100,000 cubic yards more than the estimated amount.

Larry Sturgis. The Summer Hotel contract greater quantities of rock than very well-equipped in Baltimore No. 2. The rock excavation work was increased by over 20,000 cubic yards, and the excavation work was increased by about 30,000 cubic yards.

Larry Sturgis. The rock excavation was in the same line in about 70,000 cubic yards more than that provided for in Baltimore No. 2.

The Journal in all Pennsylvania is a very small line that has in Baltimore No. 2, but in the development of the Bailey provision that have been adopted, it has like also Baltimore No. 2 was provided. The excavation on Bailey is larger than that found in Baltimore No. 2, but the development work was

made in the design so as to gain flexibility and efficiency. It is fair to allow about $400,000 more than Estimate No. 2 for the revised design of the concrete work of the Power House.

Equipment. The general design and cost of the equipment as itemized in Estimate No. 2 is similar to that installed, if due allowance be made for the difference in capacity of the units purchased, as compared with those of Estimate No. 2. A reasonable allowance for this would be a sum on the order of $300,000.

Bridges. The Bridges and Crossings cost much more than was contemplated in Estimate No. 2. This is due in part to the longer spans and heavier structures finally used, as well as the difficulties encountered before and during construction. The comparison of the estimate with the records of cost is complex. A reasonable allowance for the increased estimated costs due to the circumstances encountered amounts to a very large figure, probably on the order of a million dollars.

Right-of-Way. The original Right-of-Way estimated upon was sufficient for a single canal with a flow capacity of 10,000 cubic feet per second. The Right-of-Way purchased is sufficient for two or three canals side by side, and for the disposal of spoil from more than one whole canal. While the actual expenditure is about $1,424,000, a large part of this amount is not chargeable entirely against the present development, as it represents a recoverable asset. A reasonable allowance for Right-of-Way for a six-unit plant is about $1,000,000, being $400,000 greater than Estimate No. 2.

made in the design so as to gain [illegible] and efficiency. It is felt it allow about $[illegible] for each [illegible] to cover the various items of the [illegible] work of the Power House.

Building. The general design and [illegible] of the building as indicated in Estimate No. 2 is similar to that [illegible]. If the allowance be made for the difference in capacity of the units proposed, as compared with those of Estimate No. 2, a reasonable allowance for this would be a sum in the order of $[illegible].

Boilers. The foundations and [illegible] cost much more than was anticipated in Estimate No. 2. This [illegible] the [illegible] and [illegible] very finally [illegible], as well as the [illegible] [illegible] and [illegible] operations. The [illegible] of the [illegible] [illegible] [illegible] plan. A reasonable allowance for the increased [illegible] would be in the [illegible] [illegible] [illegible] of a [illegible].

Plant-at-Sea. The [illegible] [illegible] [illegible] for a single [illegible] with a flow capacity of [illegible] [illegible] per second. The [illegible] [illegible] [illegible] for the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] being $600,000 greater than Estimate No. 2.

Miscellaneous. The service tunnel and the sundries check closely with Estimate No. 2.

The items of expenditure for the power house railway, plant salvage, stores and so forth, were apparently not included in Estimate No. 2, unless in the unit costs or in the general allowance for overhead costs during construction.

In order to compare the total of $24,316,815 of Estimate No. 2 with the total of $64,325,000 for the six-unit plant as built, it is necessary to place them as nearly as possible upon the same basis and to contrast the conditions in 1917 with those actually found during construction.

Revision of Estimate No. 2 based on quantities as built.

Based on the quantities contained in the plant as built, Estimate No. 2 would have appeared as follows:

Total of Estimate No. 2 with quantities given therein		$24,316,815
Additional Quantities:		
Change in intake for present plant	$1,500,000	
Canal, 1,000,000 cu.yds. dredging at .20	200,000	
1,300,000 cu.yds. earth at .27	350,000	
750,000 cu.yds. rock at .98	735,000	
140,000 cu.yds. concrete at 12.00 ..	1,680,000	
800,000 cu.yds. rip-rap at 1.50	1,200,000	
Forebay, 125,000 cu.yds. rock at .98	120,000	
Screen House, 20,000 cu. yds. rock at 1.00 ...	20,000	
16,000 cu. yds. concrete at 12.00	190,000	
Power House, 75,000 cu. yds. rock at 1.50 ...	110,000	
changed concrete and superstructure, say,	400,000	
equipment, 30,000 H.P. additional	300,000	
Bridges, about	1,000,000	
Right-of-Way, additional lands, say, ...	400,000	
	$8,205,000	
Engineering, contingencies, administration and so forth, and interest during construction, 32½ per cent.	2,666,625	10,871,625
Total for Estimate No. 2 based on quantities as built		$35,188,440

Estimated Cost to Complete Six-unit Plant.

Up to March 31st, 1922, the total expenditures in connection with the plant amounted to $62,182,623, of which several millions of dollars represent recoverable assets in the form of plant salvage, stores and so forth, making the net amount chargeable against the plant on the order of $57,000,000 or $58,000,000 at that date. On page M-24 an estimated net cost of $64,325,000 is derived for a six-unit plant. It should be borne in mind that the exact amount is dependent upon the proportion of certain component parts considered as chargeable against the six-unit plant which is but a fractional part of the ultimate installation. By making other allowances for such items as right-of-way, plant salvage and so forth, the estimated cost may be found, on the completion of the cost figures, to reach $66,000,000 or $67,000,000. Absolute figures of cost are obtainable only on the entire completion of the whole development.

An analysis of the total expenditure of $62,182,623 to March 31st, 1922, has been made, and divided amongst the items of labour, materials, permanent equipment, plant and miscellaneous overhead costs. A similar analysis has also been made of the amount of $64,325,000 fairly chargeable against the completed six-unit plant. The table below shows these analyses:

Items	Gross Expenditures to March 31st, 1922.		Estimated Net Amounts for Complete Six-unit Plant
Labour	$20,243,000	.....	$22,000,000
Materials	10,797,000	.....	12,000,000*

(Table concluded on following page)

Estimated Cost to Erect the Air-Craft Plant

The is Lamb Star, Jr., the total expenditure to construct and the plant amounts to $[illegible], of which several millions of dollars [illegible] Transcontinental Airways in the form of plant entrance, stores and [illegible] the [illegible] electrically equipped the plant to the extent of $[illegible] to $[illegible] at that date. The page 5-21 is estimated not just of $[illegible] is devoted for a air-craft plant. It should be noted in view that the [illegible] amount to depreciation upon the properties of certain companies [illegible] is merely the air-craft plant which is but a [illegible] part of the ultimate installation. [illegible] for each [illegible] as right-of-way, plant factory and so forth, the estimated cost may be found, on the [illegible] of the [illegible] figures, to reach $[illegible] to $[illegible]. Showing figures of most are misleading only as the entire completion of the whole development.

An analysis of the total expenditure of $[illegible] to Lamb Star, Jr., has been made, and divided amongst the items of labor, materials, production equipment, plant and miscellaneous overhead costs. A similar analysis has also been made of the amount of $[illegible] yearly depreciation against the completed air-craft plant. The table follows these matters:

Item	Cost Incurred Prior to Lamb Star, Jr.	Estimated for Lamb Star, Jr.	Completed Air-Craft Plant
Labour	.....	$[illegible]	$[illegible]
Materials	.....	[illegible]	[illegible]

(Table continued on following page)

(Table Continued)

Items	Gross Expenditures to March 31st, 1922.		Estimated Net Amounts for Complete Six-unit Plant
Permanent Equipment	$ 8,791,000	.....	$10,000,000
Plant	10,024,000	.....	7,000,000**
Miscellaneous, overhead, interest and administration	12,327,623	.....	13,325,000
Totals	$62,182,623	.....	$64,325,000

* Stores salvage deducted. ** Salvage deducted.

Abnormal Conditions.

The expenditures on the development were largest in the years 1918, 1919, 1920 and 1921, increasing in amount as the years passed. During 1919, 1920 and 1921 material and labour costs were relatively high and the efficiency of labour was low. The general conditions obtaining were very unfavourable for construction, to such an extent, indeed, that ordinary construction was deferred and in many instances stopped, to give way to war needs or to await the completion of the post-war re-establishment. Mr. Acres says he is firm in his conviction that the excavation work of the Canal could not have been completed at an earlier date under the circumstances encountered. The faces of the rock excavation on the sides of the Canal were lined with concrete as the result of a decision to increase the capacity of the Canal, subsequent to No. 2 Estimate. Until the rock excavation in the Canal had been finished it was not possible to make the concrete lining. Moreover, it would not have been prudent to expose the concrete lining through a winter season, so it was necessary to complete it in a working season during the spring, summer and autumn of the same year. The

(Table continued)

Item	Total Expenditure to June 30, 1930.	Difference Not Accounted for Equals Pile-Driver Plant
Pressure Tunnel	$ [illegible]	$[illegible]
Plant	[illegible]	[illegible]
Miscellaneous, overhead, interest and administration		
Site	[illegible]	[illegible]
Totals	$[illegible]	$[illegible]

* Figure not given Entered. ** Included Elsewhere.

ADDENDUM (Continued).

The expenditure on the development work between in the years 1928, 1929, 1930 and 1931, increasing to double on the year preceed. Actual size, 1928 and 1929 material and labour costs were [illegible] and the efficiency of labour was low. The general conditions affecting work very unfavourable due maintenance, as well as safety. Indeed, our existing installation was burned and in many instances stopped. In view may to our work or to avoid the employment of the pressure pre-installment. Mr. Jones says he is clear in his memoriales that the negotiations with if the Tunnel could not very long maintained at an earlier date under the circumstances mentioned. The issue of the work construction on the side of the Tunnel was lead also progress as the result of a decision to increase the capacity of the Tunnel, subsequent to 30.6.1930, (sic) The work commenced in the Tunnel but been finished it was not possible to make the necessary finish. However, it would not have been possible to expand the generate finish change a greater amount, so it was necessary to complete it in a weekly service before the spring, summer and autumn of the same year. The

Power House and the Screen House were useless until the Canal was ready to serve them, and it would have been imprudent to have them finished and standing idle. All these factors combined with others, resulted in congesting the heavy construction period into less than two years. Unfortunately, these years were unique in their unforeseen abnormal conditions.

In order to determine the additional expenditure of money chargeable to the abnormal conditions, a close study has been made of the records, in comparison with the conditions obtaining when Estimate No. 2 was prepared.

Abnormal Wages Expenditure.

The analysis of the wages expenditure has already been dealt with in the first part of this Chapter, showing, briefly, that of the total of the pay-rolls up to December 31st, 1921, amounting to $19,896,657, or, say, $20,000,000, about $7,000,000 is accounted for by increase in wage rates over 1917, and about $4,500,000 represents decreased output per man-hour as compared with 1917, leaving about $8,500,000 as normal wages expenditure for the plant as built up to the date above named. This normal wages expenditure would be reduced to about $6,100,000 for the quantities in Estimate No. 2. One of the serious factors entering into wages expenditure was that of labour turnover. During the whole construction period it was difficult to secure labour, and even more difficult to retain the men after they had been engaged.

Abnormal Materials Expenditure.

From corresponding records relating to the cost of materials and equipment

Power Board and the Ryman Hotel were analyzed until the Board was ready to write them, and it would have been impossible to have them finished and effective till the Power Factors conditions with return, resulted in extending the Lamp Manufacture period into less than two years. Unfortunately, these years were used in their entirely unknown conditions.

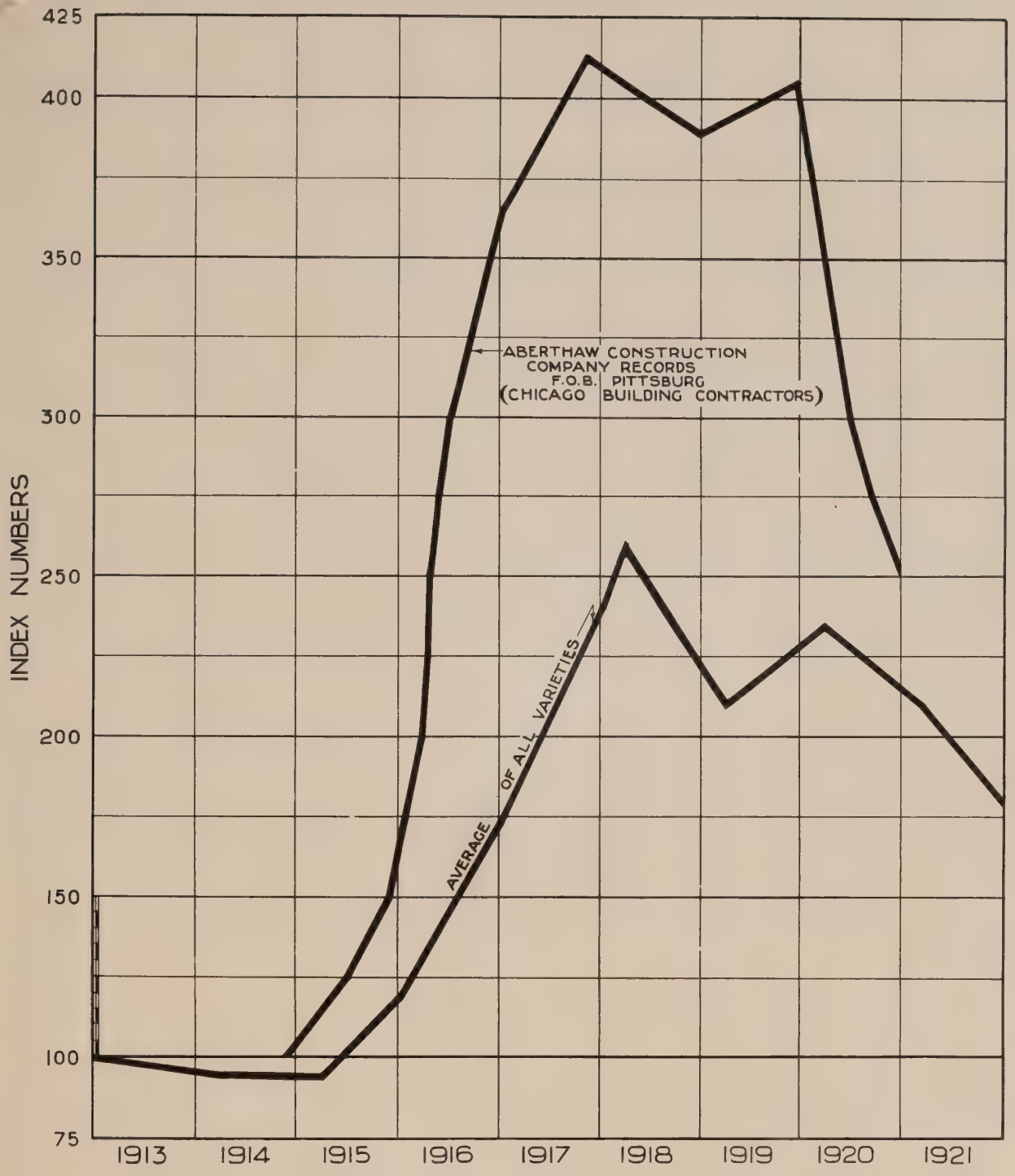
In order to determine the additional expenditure of money necessary in the changed conditions, a close study has been made of the results, in comparison with the conditions indicated when Bonnaire Co. I was projected.

Changed Water Requirements.

The analysis of the water requirements has already been built into in the first part of this Chapter, showing, briefly, that at the time of the Co-Partnership of 1st December 1921, amounting to $19,484,427, an, say, $20,000,000, about $7,000,000 is required for improvements in water rates over 1921, and about $4,000,000 requirements Government orders for sub-divisions of Nassau city, leaving about $8,000,000 as normal water expenditure for the time given as well up to the date above named. This normal water expenditure would be reduced to about $6,000,000 for the quantities in Bonnaire Co. I. One of the serious Factors affecting this water expenditure was that of labour shortage. During the whole construction period it was difficult to secure labour, and that was difficult to retain the men after they had been engaged.

Electrical Requirements Changed Here.

The corresponding figures relating to the work of electrical and engineers



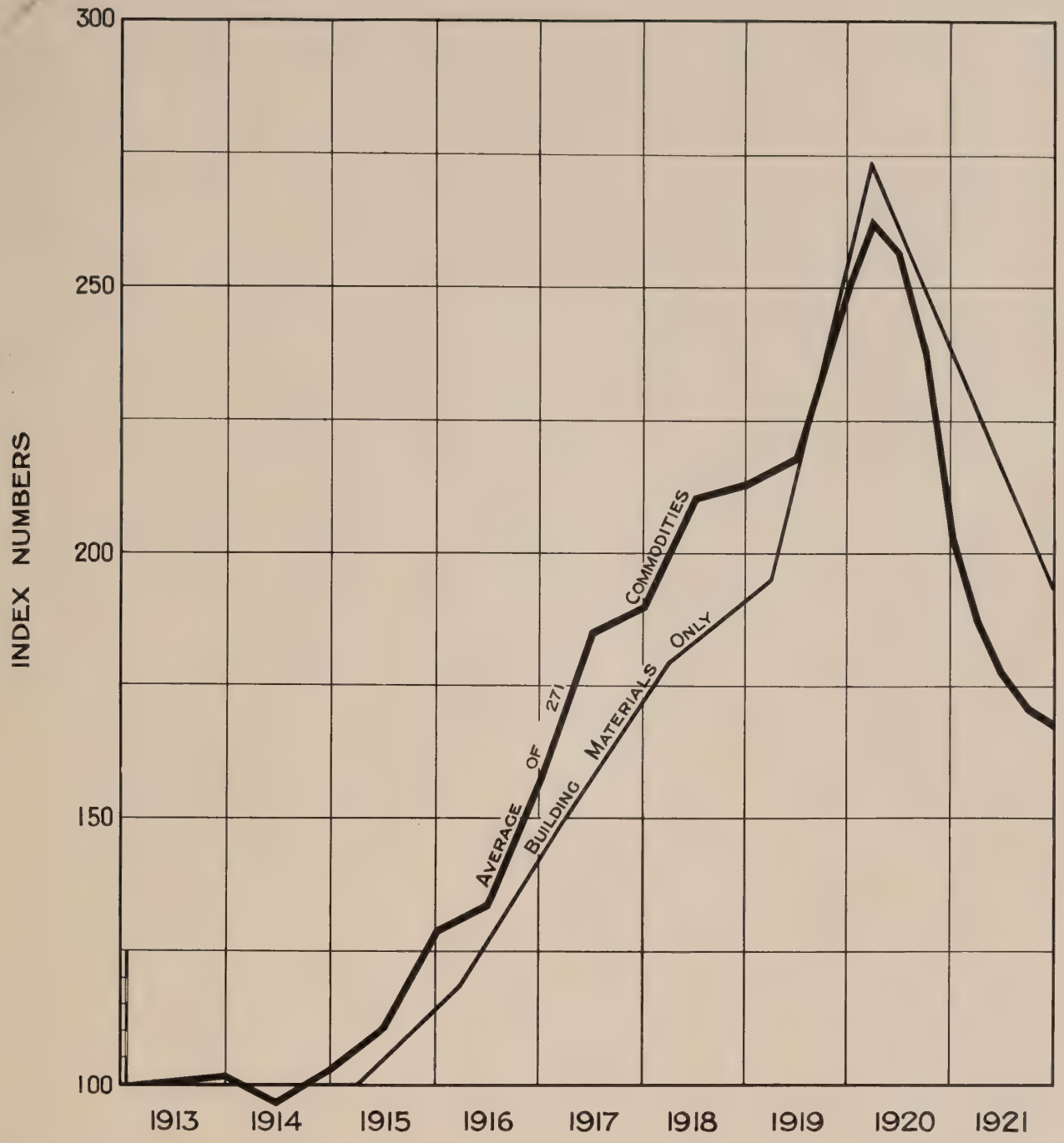
Note:
Chart Based on The Labour Gazette April, 1922

HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
QUEENSTON-CHIPPAWA POWER DEVELOPMENT

IRON AND STEEL INDEX NUMBERS BASED ON THE LABOUR GAZETTE

Toronto, July 27th 1923. Made by [illegible] Checked by [illegible]

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

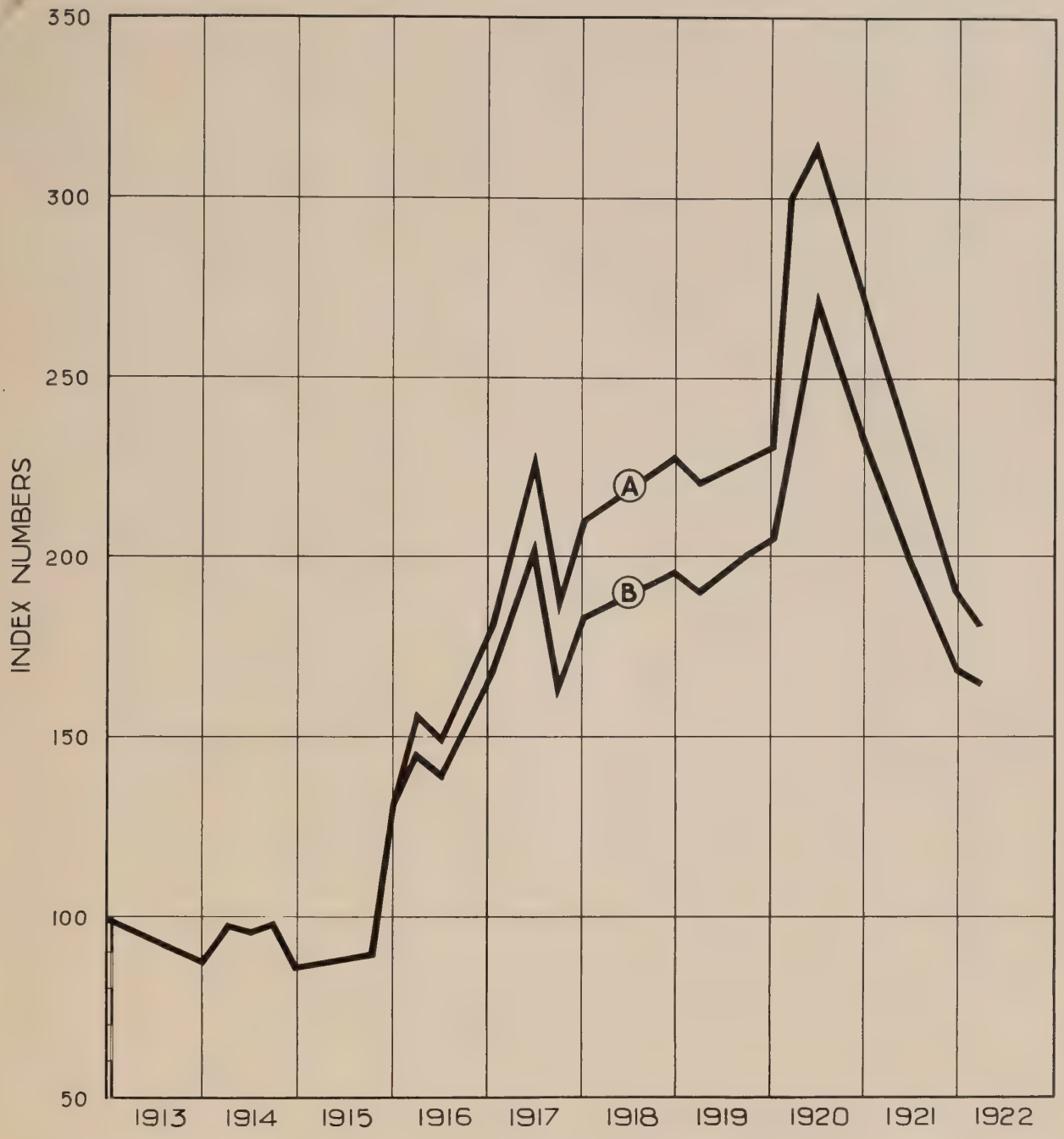


Note:
Chart Based on The Labour Gazette, April 1922.

HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
QUEENSTON-CHIPPAWA POWER DEVELOPMENT

WHOLESALE PRICE INDEX NUMBERS BASED ON THE LABOUR GAZETTE

Toronto, July 27th, 1923. Made by GEB., Checked by L.J.H.
WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS



A – Deduced from Construction Cost Index Numbers from Engineering News-Record of Jan. 5th. 1922 and a Labour Efficiency of 100% in 1913 and 60% in 1920

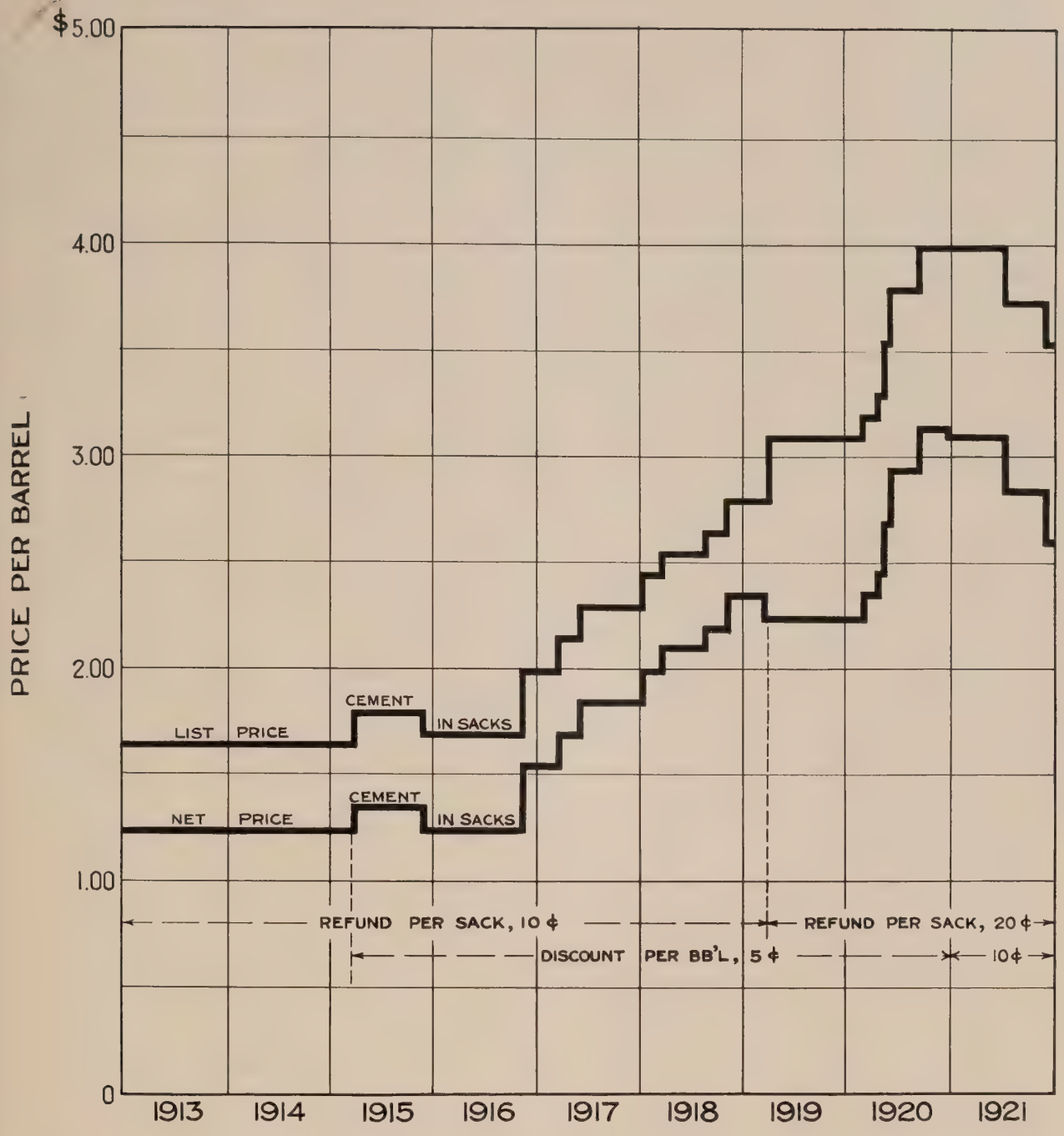
B – Deduced from Construction Cost Index Numbers from Enginering News-Record of Jan. 5th. 1922

Hydro-Electric Inquiry Commission
W. D. Gregory, Chairman
Queenston-Chippawa Power Development

COST INDEX NUMBERS BASED ON ENGINEERING NEWS-RECORD

Toronto, July 27th, 1923. Made by [illegible] Checked by [illegible]

Walter J. Francis & Company
Consulting Engineers



HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY, CHAIRMAN

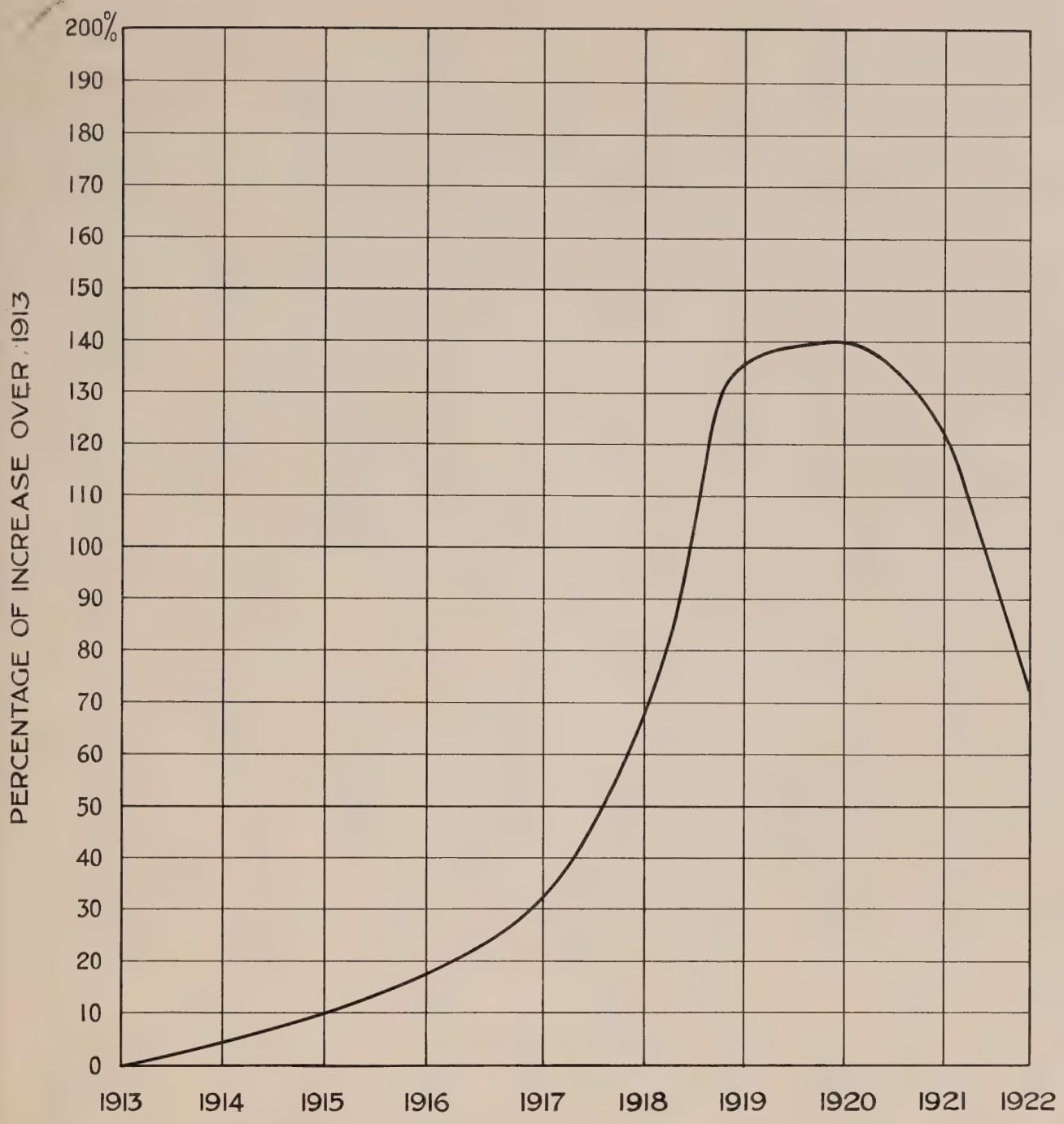
QUEENSTON-CHIPPAWA POWER DEVELOPMENT

CURVE OF PORTLAND CEMENT PRICES AT NIAGARA FALLS, ONTARIO BASED ON CANADA CEMENT Co. DATA

Toronto, July 27th, 1923. Made by G.E.B., Checked by L.D.H.

WALTER J. FRANCIS & COMPANY

CONSULTING ENGINEERS



NOTE:
THE ABOVE CURVE IS PLOTTED FROM DATA FURNISHED BY FRASER, BRACE, LIMITED, FROM THEIR RECORDS OF THE FOLLOWING WORKS:
CEDARS RAPIDS DEVELOPMENT, ST. LAWRENCE RIVER
GOUIN DAM, ST. MAURICE RIVER
BIG EDDY DAM, SPANISH RIVER
(FOR INTERNATIONAL NICKEL COMPANY OF CANADA LIMITED)
CHUTE AUX GALETS DEVELOPMENT, SHIPSHAW RIVER
(FOR PRICE BROTHERS & CO., LIMITED)
GREAT FALLS DEVELOPMENT, WINNIPEG RIVER
(FOR MANITOBA POWER COMPANY LIMITED)

HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

PERCENTAGE OF INCREASE OF CONSTRUCTION COSTS FRASER, BRACE, LIMITED

Toronto, July 27th, 1923. Made by GEB. Checked by W.D.A.

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

an estimate has been made of the cost of these items under 1917 conditions. The index numbers and percentage cost records of many construction commodities including steel, cement, crushed stone, timber, tiles, ties, poles, brick, lime, rails, coal, piles, dynamite and so forth have been examined and the amounts paid year by year for supplies and materials have been noted. A number of curves have been included herewith as pages M-34 to M-37 to show several of these records. Applying these costs as a weighted mean to the purchases made by the Hydro-Electric Power Commission, it is found that the total cost of the ordinary materials amounting to $10,797,000 as purchased would have been about $7,500,000 at 1917 prices, while the estimated amount of $12,000,000 for the complete six-unit plant would be reduced to about $8,300,000.

The diagram included herewith as page M-38 shows the percentage of increase of construction costs as experienced by Messrs. Fraser, Brace, Limited, General Contractors, on large hydro-electric and similar construction work in Canada during the period of study and construction of the Queenston-Chippawa Power Development, illustrating the trend of costs on what were probably the largest comparable Canadian construction works of the period, outside of the Queenston-Chippawa Power Development, which was much greater in size.

Abnormal Equipment Expenditure.

The item for permanent equipment amounting to $8,791,000 is not subject to the same degree of yearly fluctuation as the ordinary materials, but, judging by contract prices of similar manufactured equipment, it would appear that this

An estimate has been made of the cost of these items under 1917 conditions. The Lake Superior and Pennsylvania coal industry of today depicted considerable installing steel, cement stone, slater, tiler, tinsmith, plumber, brick, roofing, glass, electric and so forth have been considered and the amounts will great by your for workmen and materials have been noted. A number of matters have been included herewith on pages 3-6A to 3-6F in order to show between these matters. Applying these costs to a valuation made in the Pittsburgh region by the Open-Shop Construction Company Foundation, it is found that the total cost of the ordinary materials necessary to $20,777,000 to produced would have been about $7,800,000 as 1917 prices, while the estimated amount of $2,300,000 for the complete sky-work alone would be about $8,000,000.

The diagram included herewith at page 3-6E shows the percentage of increase of construction costs as separated by items, frame, brick, tiling, cement Industries, as large Open-shop and similar construction mid in Chicago during the period of study and construction of the Chicago-Gilgoan Tower Development. Illustrating the trend of costs in what were probably the lowest organized Industry construction works of the period, outside of the Chicago-Gilgoan Tower Development, while one most greater in size.

Improved Industrial Conditions.

The idea for permanent equipment amounting to $2,171,172 is not subject to the same degree of hourly fluctuation as the ordinary materials, but, judging by recent prices of similar substantial equipment, it would appear that this

item would have cost about $5,500,000 at 1917 prices, and that the equipment for the complete six-unit plant would have been about $7,700,000.

Abnormal Plant Expenditure.

From an examination of construction plant prices it is apparent that the amount of $10,024,000 expended for plant would have been about $5,000,000 at 1917 prices. The salvage value would be correspondingly reduced, however, if the prices had remained the same as in 1917, so that the net amount for construction plant costs for the complete six-unit plant would have been about $3,500,000 or $4,000,000.

Miscellaneous Overhead Costs.

The item of miscellaneous overhead costs during construction, engineering, superintendence, administration, interest, and so forth, amounting to about $12,327,623 as at March 31st, 1922, is approximately 25 per cent. of the total of the other items.

Estimated Cost of Six-unit Plant as Built, 1917 Conditions.

Summing up the above, had prices and conditions remained as in 1917, the cost of the complete six-unit plant as being constructed and as almost completed would have been about as follows:

then would have cost about $2,800,000 at 1917 prices, and that the original for the complete air-cell plant would have cost $7,700,000.

Comparison Plant Investigation.

From an examination of contractors plant prices it is apparent that the amount of $12,000,000 expended for plant would have been about $2,000,000 at 1917 prices. The salvage value would be correspondingly reduced, however, if the prices that prevailed the case in 1917, at that the net amount for an air-cell plant would for the complete air-cell plant would have been about $2,000,000 to $4,000,000.

Miscellaneous Personal Items.

The item of miscellaneous personal costs during construction, engineering, superintendence, administration, interest, and so forth, amounting to about $12,327,000 on a cash basis, 1918, is approximately 27 per cent. of the total of the other items.

Estimated Cost of Air-Cell Plant on Basis, 1917 Conditions.

Considering the cases, and prices and conditions prevailing as in 1917, the cost of the complete air-cell plant as being constructed and as it would have been about as follows:

Estimated Cost of Six-Unit Plant, 1917 Conditions

Labour	$10,000,000
Materials	8,300,000
Permanent equipment	7,700,000
Plant	3,750,000
Miscellaneous, overhead, interest and administration, 25 per cent	7,562,000
Estimated Cost of Six-unit Plant under 1917 conditions	$37,312,000

This estimate, $37,312,000, comes within 7 per cent. of the estimate of $35,188,440 which would have been the total of Estimate No. 2 if the quantities in the unfinished work had been used for estimating purposes in 1917. The unwatering conditions encountered would undoubtedly account for a considerable proportion of the difference, and the strike in the summer of 1920 also increased the cost of the work materially.

Estimate No. 2-A and Estimate No. 2-B.

Estimate No. 2, made on November 27th, 1917, was used in the work throughout, modified by two later revisions, the first of which was dated January 3rd, 1919, and has been referred to by us as Estimate No. 2-A. The second revision which we know as Estimate No. 2-B was made late in 1919. Estimate No. 2 was the basis of all these estimates. Estimate No. 2-A, in brief, constituted the additions due principally to the use of the concrete lining for the canal, and made a net addition of $786,100.00 to Estimate No. 2, or a total estimated cost of $25,102,915.00. Estimate No. 2-B added the sum necessary for the special design of intake, and made a net addition of $1,922,720, or a total of

Estimated Cost of Big-Dam Plan, 1917 Conditions

Labor	$10,000,000
Materials	8,800,000
Temporary equipment	1,700,000
Plant	2,700,000
Miscellaneous, including:	
Interest and administration, 12 per cent	7,800,000
Estimated Cost of Big-Dam Plan under 1917 conditions	$27,000,000

This estimate, $27,000,000, shows within 7 per cent, or the difference of $2,000,000 which could fairly have been the total of Estimate No. 2 if the conditions in the preliminary work had been and the estimating progressed in 1917. The excavating equipment was [illegible] and [illegible] adequately adapted for a substantial proportion of the difference, and the strike in the summer of 1920 also increased the cost of the work materially.

Estimate No. 3-1 and Estimate No. 3-2.

Estimate No. 3, made on November 8th, 1917, was based in the work through-out, modified by the 3 foot variation. The first or Dam-and-Lake Reality Plan, 1918, and has been reduced to by so as Estimate No. 3-1. The second variation which we have as Estimate No. 3-2 was made late in 1921. Estimate No. 3 was the basis of all these estimates. Estimate No. 3-1, in brief, constituted the addition due principally to the use of the reservoir instead of the canal, and made a net addition of $14,100,000 to Estimate No. 3, or a total estimated cost of $28,100,000. Estimate No. 3-2 added 34-per centum for the dynamic design of intake, and made a net addition of $2,400,000, or a total of

$27,025,635, which includes the gathering tubes not yet constructed but estimated to cost about $500,000.00.

On a basis similar to that used in the comparison of Estimate No. 2 with a six-unit plant, as set forth on page M-24 and subsequent pages, the following table shows a comparison between Estimate No. 2-B and a plant as built complete for six units.

Comparison of Estimate No. 2-B with Six-unit Plant as Built

Items	Estimate No. 2-B	Plant as built - Complete for six units.
Intake	$2,895,420	$ 2,500,000
Welland River	535,384	1,500,000
Canal	8,240,838	36,500,000
Forebay	399,874	1,250,000
Screen and Gate House	360,708	1,750,000
Bridges	610,323	2,650,000
Right-of-way	600,000	1,000,000
Penstocks	409,236	1,250,000
Power House	1,660,150	3,500,000
Power House Machinery and Equipment	5,018,000	6,500,000
Miscellaneous	175,000	150,000
	$20,903,933	$58,550,000
Less: Estimated Cost of Gathering Tubes not constructed	500,000	
	$20,403,933	$58,550,000
Engineering, Contingencies, Administration and so forth	4,745,278	-
Interest during construction.	1,376,424	4,750,000
	$26,525,635	$63,300,000
Power House Railway		200,000
Plant Salvage		3,000,000
Stores		1,650,000
Carried forward		$68,150,000

$97,222,222, which includes the potential sales not yet incorporated in valuations and to cost about $500,000.00.

In a manner similar to that used in the consolidation of Exhibits No. 2 with a six-month phase, as set forth on pages 24-24 and preceding pages, the following table shows a depreciation reserve Exhibit No. 2-2 and a plan as well through for six months.

Reconciliation of Exhibits No. 2-2 with Six-month Plan as Shown

Item	Exhibit No. 2-2	Plan as Shown - Complete for six months.
Cash	.....	..... $ 2,000,000
Salaried Staff	.....	 1,300,000
Guard	2,300,000	 75,000,000
Property	.....	 1,100,000
Barges and Data Cases	275,275	 1,700,000
Buildings	340,700	 2,000,000
Pick-up-and-Vary	610,230	 1,000,000
Power Plans	800,000	 3,200,000
Power Plans Machinery	409,236	 2,000,000
and Equipment	1,640,130	 4,000,000
Miscellaneous	5,010,000	 100,000
	170,000	
	$20,000,000	$96,000,000

Less: Estimated Cost of Delivering Sales not accounted ..... 500,000 ..... ____

$20,400,000 ..... $96,000,000

Engineering, Buildings, Administration and so forth 4,740,000
Interest During Construction 1,270,000
$26,410,000 ..... $96,000,000

Power Plans Salvage 500,000
Plant Salvage 2,000,000
Stores 1,000,000
Carried Forward $96,000,000

Brought forward	$68,150,000
Expenses of Plant Salvage	110,000
Miscellaneous Sales and Work Orders	60,000
Suspense Account	5,000
Total	$68,325,000
Credit Plant, Stores Account and so forth, say	4,000,000
Net Total Cost of Six-unit Plant as constructed	$64,325,000
Net Total, Estimate No. 2-B.....	$26,525,635
Difference between Estimate No. 2-B and Estimated Cost as Built	$37,799,365

Basis of Estimate No. 2.

A complete transcription of Estimate No. 2 was submitted to the Hydro-Electric Inquiry Commission in June, 1922. As it is voluminous and in great detail, comprising twenty-six pages of report text with fourteen appendices, together with many plans and diagrams, and other supplementary data, it is not being repeated in this discussion.

Progress Schedule. A study has been made of the basis of Estimate No. 2 regarding the progress schedule laid down therein as compared with the progress made under the abnormal conditions encountered during construction.

In Appendices 5 and 6 of Estimate No. 2 the program of operations for the canal work and the progress schedule for construction are set forth. The total quantities for earth and rock excavation, the location of the excavation work and the plant proposed are shown in the following table:

APPROXIMATE SCHEDULE CURVES

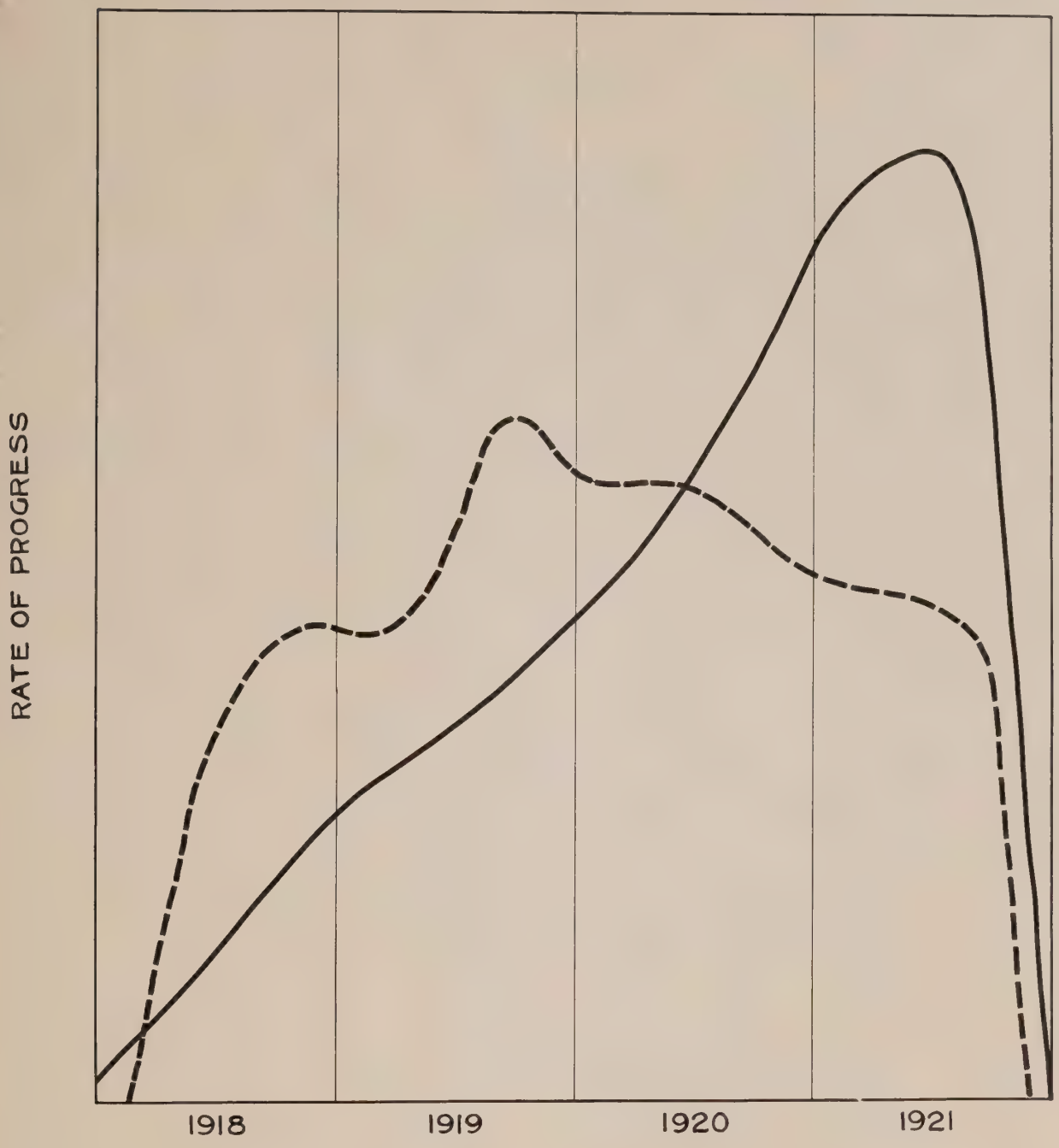
Brought forward	$00,180,000
Expenses of Plant Delivery	18,000
Miscellaneous Sales and Net Orders	60,000
Expenses Unusual	
.....	
Total assets	$
Net Profit Part of 10-mill Plant in Manufacture	$
Net Total, Nothing Ar. 3-2	$4,000,000
Difference between Totals 2. 3-2 and Delivered Plant as Built	$80,170,000

Data of Balance Sh. 2.

A complete inventory of Company No. 2 was submitted to the Injury-Electric Supply Tribunal in June 1920. It is in volumes and is quite detail, including hundreds of pages of report and with further explanations, together with many plans and diagrams, and other supplementary data, it is not being reproduced in this discussion.

Structure Schedule. A study has been made of the basis of estimate Sh. 2 providing the proposed schedule 1-11 does therein as presented with the requirements made under the changed conditions mentioned further constructions.

In Appendices 2 and 3 of Exhibit Sh. 2 the progress of investigation the road went and the proposed schedule for construction are set forth. The total expenditure for work and tool accounting, the Junction of the accounting with the plant progress are given in the following section.



THE FULL LINE REPRESENTS APPROXIMATELY BY PERCENTAGE THE PROGRESS OF THE WORK AS CONSTRUCTED

THE DOTTED LINE REPRESENTS APPROXIMATELY BY PERCENTAGE THE SCHEDULE SET OUT IN ESTIMATE № 2

HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY, CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

APPROXIMATE SCHEDULE CURVES

Toronto, July 27th, 1923. Made by G.S.R. Checked by W.J.F.

WALTER J. FRANCIS & COMPANY

CONSULTING ENGINEERS

Quantities of Earth and Rock Excavation, Estimate No. 2

Element of Work	Material	Quantities Cubic Yards	Plant Proposed
Welland River	Earth	1,075,000	Cableway
Canal	Earth	9,250,000	Four shovels - two 225-B and two 103-C
Canal	Rock	3,600,000	Four shovels - two 225-B and two 103-C
Forebay	Earth	45,000	One shovel - 103-C
Forebay	Rock	400,000	One shovel - 103-C
Power House	Rock	400,000	Four derricks

The schedule for the above excavation work as laid out in Estimate No. 2 was as follows:

COPY

Schedule of Excavation Work, Estimate No. 2

Element of Work	Material	Year	Quantities Cubic Yards	Percentage per Year
Welland River	Earth ...	1918 ...	500,000	46.5
		1919 ...	500,000	46.5
		1920 ...	75,000	7.0
				100.0%
Canal	Earth ...	1918 ...	1,705,250	18.4
		1919 ...	2,937,000	31.7
		1920 ...	2,524,500	27.3
		1921 ...	2,083,250	22.6
				100.0%
Canal	Rock ...	1918 ...	166,700	4.7
		1919 ...	1,251,900	34.8
		1920 ...	1,510,700	41.8
		1921 ...	670,700	18.7
				100.0%
Forebay	Earth ...	1918 ...	45,000	100.0%
Forebay	Rock ...	1919 ...	400,000	100.0%
Power House	Rock ...	1918 ...	200,000	50.0
		1919 ...	200,000	50.0
				100.0%

Schedule of Work and Cost Availability Estimate No. 2

Account of Work	Contract	Quantities Total Work	Cost Incurred
Walnut River	North	1,[illegible]	..... Completed
Canal	North	9,280,000	..... Four sluices - two 228-2
Canal	Dam	1,[illegible]	..... Four sluices - two 228-2
Turnbay	North	45,000	..... One sluice - 108-2
Turnbay	North	400,000	..... One sluice - 108-2
Power House	Dam	400,000	..... Four turbines

The schedule for the power generation plant as laid out in Estimate No. 2 was as follows:

Schedule of Execution Work, Estimate No. 2

Account of Work	Contract	Year	Quantities Total Work	Contractors Cost Total
Walnut River	North ...	1918 ...	270,000	..... 46.4
		1919 ...	800,000	..... 48.8
		1920 ...	75,000	..... 7.0
				100.0%
Canal	North ...	1918 ...	1,[illegible]	..... 14.4
		1919 ...	2,947,300	..... 32.7
		1920 ...	2,924,800	..... 27.3
		1921 ...	2,[illegible]	..... 25.6
				100.0%
Canal	Dam ...	1918 ...	344,700	..... 4.7
		1919 ...	1,[illegible]	..... 32.8
		1920 ...	1,810,700	..... 41.8
		1921 ...	870,700	..... 16.7
				100.0%
Turnbay	North ...	1918 ...	44,000	..... [illegible]
Turnbay	Dam ...	1918 ...	400,000	..... 100.0%
Power House	Dam ...	1918 ...	200,000	..... 50.0
		1919 ...	200,000	..... 50.0
				100.0%

It was stated by Mr. Acres that he estimated that the two 225-B shovels would handle about 40 per cent. of the earth excavation and 80 per cent. or 90 per cent. of the rock excavation, while the two 103-C shovels were to excavate the remainder scheduled for the four machines.

The estimated capacity of each type of shovel in earth and in rock was stated to be as follows:

Type of Shovel	Estimated Capacity in Ten Hours: Earth Cubic Yards	Rock Cubic Yards
225-B	5,000	3,000
103-C	3,500	2,000

The average maximum performance of the shovels over short periods of time was as shown below, although certain shovels exceeded the above estimated capacity on some occasions:

Shovel	Average Maximum Performance of Each Shovel in Ten Hours: Earth Cubic Yards	Rock Cubic Yards
No. 1 and No. 2, 225-B	4,620	1,896
No. 3 and No. 4, 103-C	2,759	1,824

The cableway excavator was scheduled to work double shift continuously, ten hours to a shift, 1,000 yards per shift.

The canal and forebay excavation equipment was scheduled to work seven months per year on a single ten-hour shift per day, and for five months per year on two eight-hour shifts per day.

The general program of construction as laid down would have made the date of completion about October, 1921, requiring over 1,000 working days, with the

It was stated by Mr. Jones (Q8) it estimated that the two 120-g aircraft would handle about 40 per cent, at the most, approaches and 20 per cent, at 10 per cent, of the peak movements, while the 120-C engine was to engage the remainder allocated for the four runways.

The estimated capacity of each type of aircraft in each one is now stated to be as follows:

Type of Aircraft	Estimated Capacity in One Hour: Each Runway Single Lane	Each Runway Double Lane
120-g	3,000	2,400
120-C	2,800	2,000

The average maximum performances of the aircraft over short periods of time are as stated below, [illegible] average measures the state estimated capacity as some conditions:

Aircraft	Average Maximum Performances of Each Aircraft in the Lanes: Each Runway Single Lane	Each Runway Double Lane
No. 1 and No. 2, 120-g	4,000	1,400
No. 3 and No. 4, 120-C	2,700	1,000

The maximum movement was estimated to take place within approximately ten hours to a shift, 1,000 yards per shift.

The usual and typical movements performed was estimated to vary during the year on a single runway only per day, and for five months per year on two eight-hour shifts per day.

The general problem of maintenance on Jail Area would have the Air of complaints about Jaldow, 1421, imposing over 1,000 working days with the

construction extending over nearly four years.

From the above data and other records, and from information derived from discussions with the engineers of the Hydro-Electric Power Commission, we have plotted curves, shown on the diagram on page M-44. The dotted line represents the proposed schedule of complete construction on a time basis, while the solid line represents an approximation of the actual progress of the work, both curves being reduced to a percentage basis, the area between the curve and the base line being 100 per cent. of the total work in each case.

The reasons for the difference in the two curves in point of time have been referred to at length in former volumes and discussed herein, but, briefly, it may be noted that the change in the design of the Canal requiring the concrete lining to be placed towards the end of the work, and the consequent change in the time of construction of the Screen House and Power House, together with the revision of the intake design, and the labour and market and other difficulties encountered, accounts to a considerable extent for the change in the program.

Unit Costs. A study has also been made of the basis of Estimate No. 2 as regards the reasonableness of the unit prices used therein.

When it was decided to proceed with development of power at Niagara, the Hydro-Electric Power Commission sent Mr. Jas. B. Goodwin and Mr. Thos. H. Hogg on a tour of inspection in May and June, 1916, to a number of places in the United States and in Canada where excavation work on a large scale was in progress. On their return they submitted a comprehensive, illustrated report to Mr. Acres,

construction extending over seventy-four years.

Once the stars, sun and other heavens, and from Intermediate Service from Greenwich with the engineers of the Sydney-Adelaide Power Construction, we have pitched tents, which is the design on page 4-6. The Artist line represents the physical outline of Australia constructed on a line nearly, while the with line represents an approximation of Greenwich progress of one week, with curves that go radiant to a perpendicular line, the area between the line and the base line being 120 per week, if the total work is well done.

The reason for the difference in the two curves is that at time zero assumed to at least in [illegible] the discussed Bertha Trip-Atlantic, is not to actual case the change in the design of the Dual Operator the electric lighting to be placed towards the end of the work, and the mechanical change in the line of construction of the Sydney Power Lines, together with the revision of the Lighting design, and the labors and control and other differentiation necessitate a considerable effort for the change in the program.

Bell Curve. A study has also been made of the work of Bertha Jr. I to record the requirements of the curve, which has been Gaussian.

When it was limited to crews with Experience of power at Niagara, the Pyle-Atlantic Power Construction made for Gen. Co. Lambda and Mr. Ohm, to keep on a task of Lighting in the end from 1914, in a manner of blows in the United States and to Canada begin mechanical sign, [illegible] to the principal to their points that established a requirements, illustrations might be Mr. Lyons.

signed by Mr. Goodwin, under date of June 26th, 1916, covering excavation methods, equipment and costs. This report was transcribed in full and was presented to the Hydro-Electric Inquiry Commission under date of May 21st, 1923, by Mr. Francis, and it should be read in conjunction with this discussion. Based on the records of the Calumet-Sag Canal near Chicago, where work comprising 7,856,000 cubic yards of earth excavation, 1,723,000 cubic yards of rock excavation, 965,000 square feet of channelling, 348,500 cubic yards of rip-rap, and 31,075 cubic yards of plain concrete and about the same amount of reinforced concrete was under contract, it was shown that the average contract prices per cubic yard for eleven different sections of the work were as follows:

Class of Work	Lowest Tender	Average of All Tenders	Average of Accepted Tenders
Earth excavation	$0.309	$0.379	$0.326
Rock excavation, channelled	0.865	0.904	0.875
Rock excavation, not channelled .	0.674	0.778	0.705
Plain concrete	5.85	7.13	6.66
Rip-rap	0.974	1.452	1.136

At Livingstone Channel in the Detroit River it was found that rock excavation amounting to about 1,227,777 cubic yards was under contract at an average price of $1.08 per cubic yard, exclusive of temporary dam work which cost in addition about $100,000. The estimated net cost to the contractor was placed at about 79 cents per cubic yard, and, allowing for the difference between the restricted space in the channel and the estimated conditions at Niagara, and also for the larger quantities at Niagara, the engineers of the Hydro-Electric Power Commission say they considered that the net cost per cubic yard of rock

excavation might be as low as 70 cents.

It is stated by Mr. Acres that the large excavating units proposed by him in Estimate No. 2 for the Queenston-Chippawa Power Development were selected upon the basis of their actual records elsewhere and upon the statements of the manufacturers regarding capacity, and that it was confidently expected by him that the large size and capacity would reduce the unit excavation costs below those found on the contracts examined. Mr. Acres further states that he considered the large excavating units to be justified in saving transportation of spoil, owing to the great heights to which they were able to deliver the spoil directly from the bucket, - in short because they were not only excavating machines but also elevating machines. His choice of motive power has already been referred to at length, and the relative performance of the steam units as compared with the electric units is fully set forth in "Chapter H, Earth and Rock Excavation, Canal." During the progress of the work the large excavating units did not operate for any great length of time at their maximum capacity for reasons which have been discussed, but the records show that on some occasions certain shovels exceeded their estimated capacity.

An analysis of the performance of the shovels of the 225-B and 103-C types has been made by Mr. Acres and compared with the performance scheduled for the plant outlined in Estimate No. 2. This information is contained in a document sent by Mr. W. W. Pope to Mr. J. H. W. Bower on July 24th, 1923. The document is entitled "Comments on Evidence Given before the Commission by Contractors on May 18th, 22nd and 23rd, 1923," and was prepared by Mr. H. G.

Acres. It consists of fifty-eight pages of text and seventeen appendices. This analysis showing unit costs for earth and rock excavation, is based on the records of the four shovels, and he has prepared estimates to show what these unit costs would have been if the four shovels had operated, (a), at their estimated capacity, and, (b), at the maximum average rate of output obtained on the work. In the case of the estimated output it would have required 1,002 days from April 1st, 1918, to complete the excavation work, which would have been finished about July 1st, 1921. In the latter case the date of completion of excavation would have been July 10th, 1922, requiring about 1,326 days.

The following table shows the comparative unit costs on the three bases discussed above:

Summary of Shovel Performance
(Two 225-B and two 103-C Shovels)

Shovels	Unit Costs from Total Performance Dollars per Cu.Yd.		Unit Costs at Continued Maximum Estimated Output Dollars per Cu.Yd.		Unit Costs at Continued Maximum Performance Dollars per Cu.Yd.	
	Earth	Rock	Earth	Rock	Earth	Rock
No. 1 and No. 2 (225-B)	0.642	3.39	0.243	1.137	0.263	1.80
No. 3 and No. 4 (103-C)	1.17	3.16	0.257	0.773	0.326	0.902
All four shovels	0.849	3.35	0.251	1.099	0.303	1.63

The above table indicates that had the shovels given their estimated output continuously the average unit costs would have been 25 cents per cubic yard for earth and $1.10 for rock, while if the shovels had kept up their best

average performance the respective unit costs would have been 30 cents for earth and $1.63 for rock. The average estimated unit costs of Estimate No. 2. were 27 cents per cubic yard for earth and 98 cents per cubic yard for rock.

The plant as built gives every indication of being properly proportioned in its several parts, and is functioning in a highly satisfactory manner.

Walter J. Francis

Consulting Engineer.

Toronto, July 27th, 1923.

COPY

COPY

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

Chapter M.

COPY

ADDENDA

Walter J. Francis.

INDEX TO CHAPTER M-ADDENDA

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross,

(M-Addenda Illus.)

LIST OF ILLUSTRATIONS

COPY

(M-Add-1)

SUPPLEMENTARY MEMORANDUM

for

CHAPTER B. - HISTORY

Chapter B, devoted to the history of the Queenston-Chippawa Power Development, was completed in July, 1922. Since that time construction work has continued, and the condition of the work at the present date, October 31st, 1923, may be briefly summarized as follows:

The Intake: The intake is complete with the exception of the gathering tubes.

The Welland River: The excavation in the Welland River is complete for five units at the plant, and in progress for a sufficient capacity for Units No. 6, 7 and 8.

The Canal: The canal is complete with the exception of a small amount of trimming on the banks and betterments at the toe of the slopes. In the earth section, some additional excavation work may be required.

The Forebay: The forebay is complete with the exception of a small amount of trimming and some grading for the spillway.

The Screen House: The screen house is complete and in operation for five units, while the substructure is complete for nine units. The superstructure is in course of completion for Units No. 6, 7 and 8.

The Power House: Units 1, 2, 3, 4 and 5 are complete and in operation; Unit No. 6 is nearly complete; for Unit No. 7, the power house concrete is ready to receive the turbines, and the excavation for the penstock is in progress; for Unit No. 8 the excavation for the power house is complete and concreting is in progress. The turbines and the generators for Units No. 6, 7 and 8 are being manufactured; for Unit No. 9 the site is cleared and a small amount of rock has been excavated.

The power house building and the electrical equipment is in progress and in various degrees of completion corresponding to the installation of the units.

Bridges: All the permanent bridges are complete with the exception of the highway bridge at Victoria Road.

General Work: The work is generally progressing towards completion, and the necessary construction forces and commissariat are being retained, while, at the same time, salvage work is being carried on with particular reference to such scrap material as pipes and fittings, rails, fastenings, timber and mechanical equipment.

SUPPLEMENTARY DESCRIPTIVE PHOTOGRAPHS

The photographs included in "Chapter E, - General Description" served to illustrate the principal features of the Queenston-Chippawa Power Development at the time Chapter E was finished in July, 1922. Three other photographs are included herewith, two showing the condition of the Power House on October 27th, 1923, and one giving a general idea of the appearance of the Power House when it will have been ultimately completed for ten main units.

To face page M-Addenda-4

No. M-1

Photograph showing

Niagara Gorge at Queenston with Queenston-Chippawa Power House in Foreground.

looking downstream.

Taken October 27th, 1923.

To face page E-AA5ccxiii-3

Fig. 1.

Telephoto Station

General View of Proposed Dam Site between Dunes.

Looking westerly from the American side of the Niagara River.

Taken October 17th, 1922.

(For enlargement see the photograph on plate E-AA5, as to numbered).

No. M-2

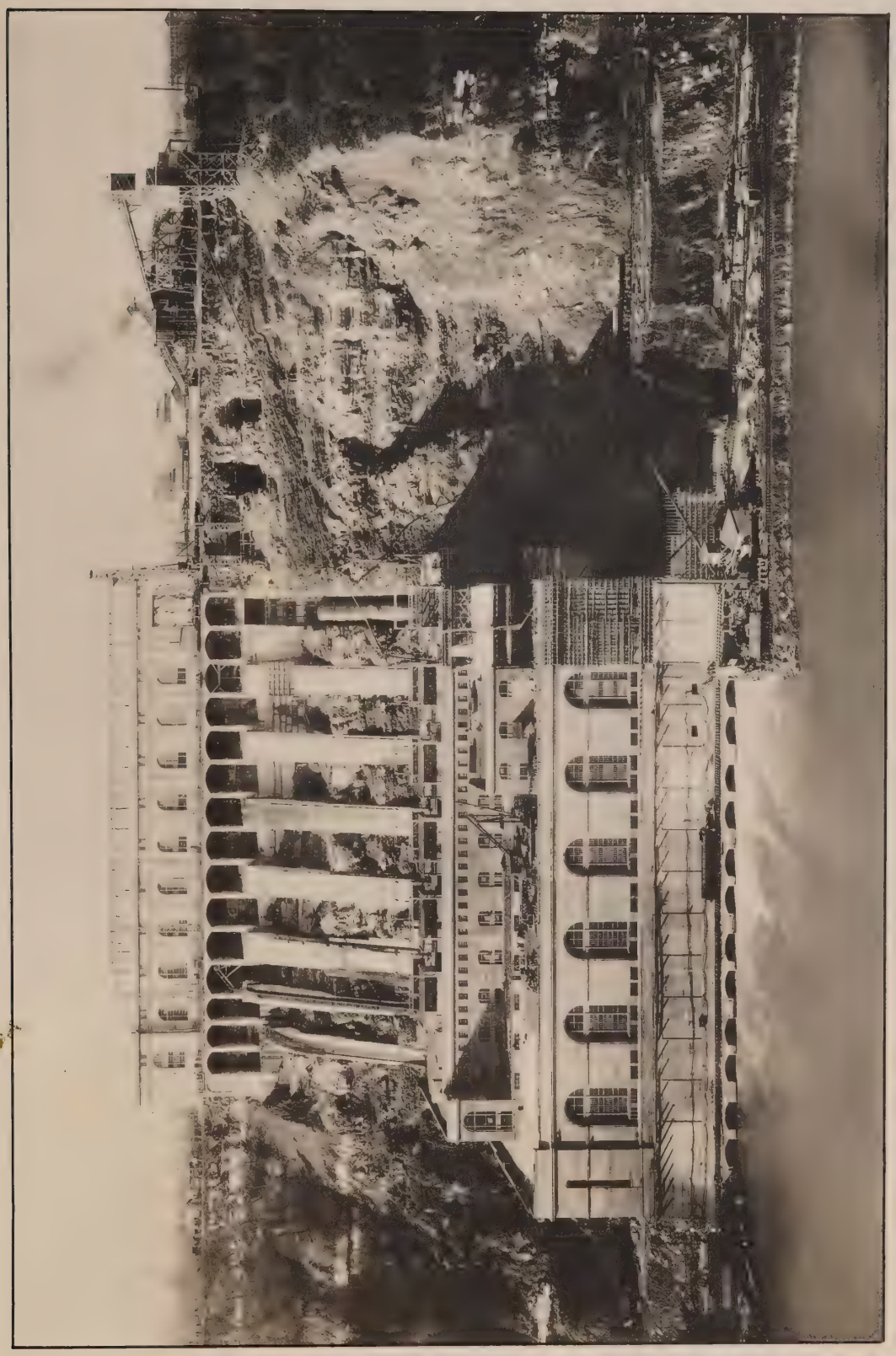
Photograph showing

General View of Power House, Penstocks and Screen House,

looking westerly from the American side of the Niagara River.

Taken October 27th, 1923.

(For comparison with photograph on page D-61, as to progress.)



No. 3-5

Thickness gauges

Manual Tire Thickness Gauge Front
Manufacturing Company

A compact pistons pair for the measuring of shrinkage in a vessel may be made using from the top of the measured in the cylinder-bore lines of two tangents, having from a tangential of vertically specially of the plant, later (before 27th, 1944.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

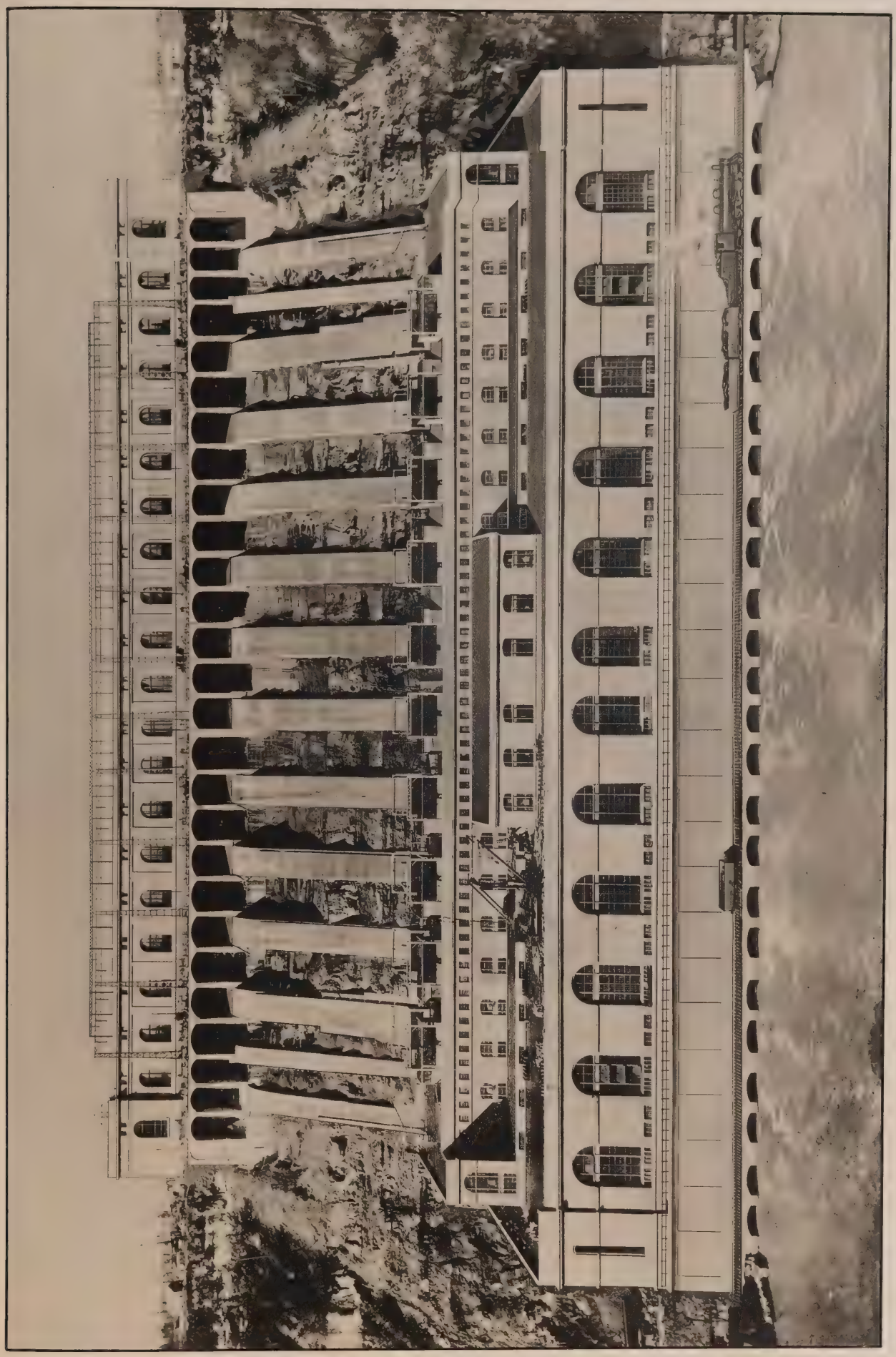
To face page M-Addenda-6

No. M-3

Photograph showing

General View of Queenston-Chippawa Power Plant if completed for Ten Main Units.

A composite picture made for the purpose of showing in a general way the whole works from the top of the escarpment to the tail-water level of Lake Ontario, derived from a photograph of practically one-half of the plant, taken October 27th, 1923.



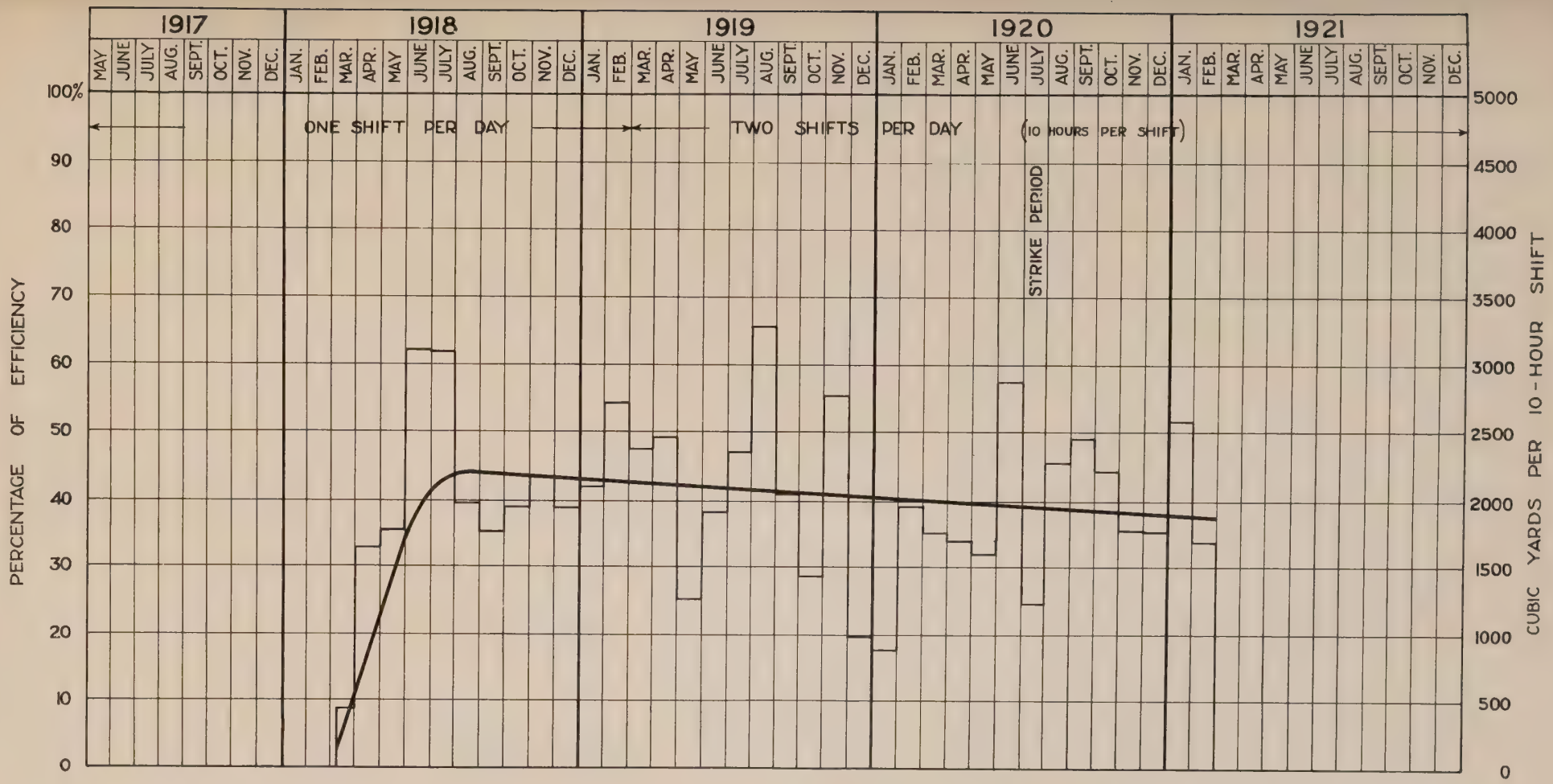
ELECTRIC SHOVEL PERFORMANCE

Subsequent to the completion of Chapter M, the Hydro-Electric Inquiry Commission requested us to analyze the records of the output of the large electric shovels and to prepare performance curves. Accordingly, we studied the records in regard to the performance of the three electric shovels, No. 1, No. 2 and No. 8, being type 225-B, and have plotted two sheets of curves, one sheet for the performance of the three shovels in earth excavation, and another in rock excavation. These curves are included herewith as pages M-Add-8 and M-Add-9. They were derived from the records of the Hydro-Electric Power Commission contained in Chapter M. The notes on the diagrams are self-explanatory.

(K-488-7)

ALTERNATE CONFIGURATIONS

Subsequent to the completion of Chapter 6, the Tyler-Sherwin Inquiry Commission requested us to analyze the results of the output of the large electric shovels and to prepare particular curves. Accordingly, we studied the records in regard to the performance of the three electric shovels, No. 1, No. 2 and No. 6, being type 320-B, and have plotted the results of tests, one sheet for the performance of the three shovels in earth excavation, and another in rock excavation. Copies of these individual charts are given K-488-8 and K-488-9. They were derived from the records of the Tyler-Sherwin Power Commission mentioned in Chapter 7. The notes in the diagrams are self-explanatory.



THE EFFICIENCY PERCENTAGES ARE BASED ON 5,000 CUBIC YARDS PER SHOVEL PER 10-HOUR SHIFT IN EARTH AS BEING 100 PER CENTUM. (AS ASSUMED IN H. E. P. C. ESTIMATE No. 2.)

THE MONTHLY AVERAGE PERFORMANCE PER SHOVEL PER 10-HOUR SHIFT IS SHOWN THUS:

THE PROGRESSIVE AVERAGE PERFORMANCE PER SHOVEL IS SHOWN THUS:

HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY, CHAIRMAN

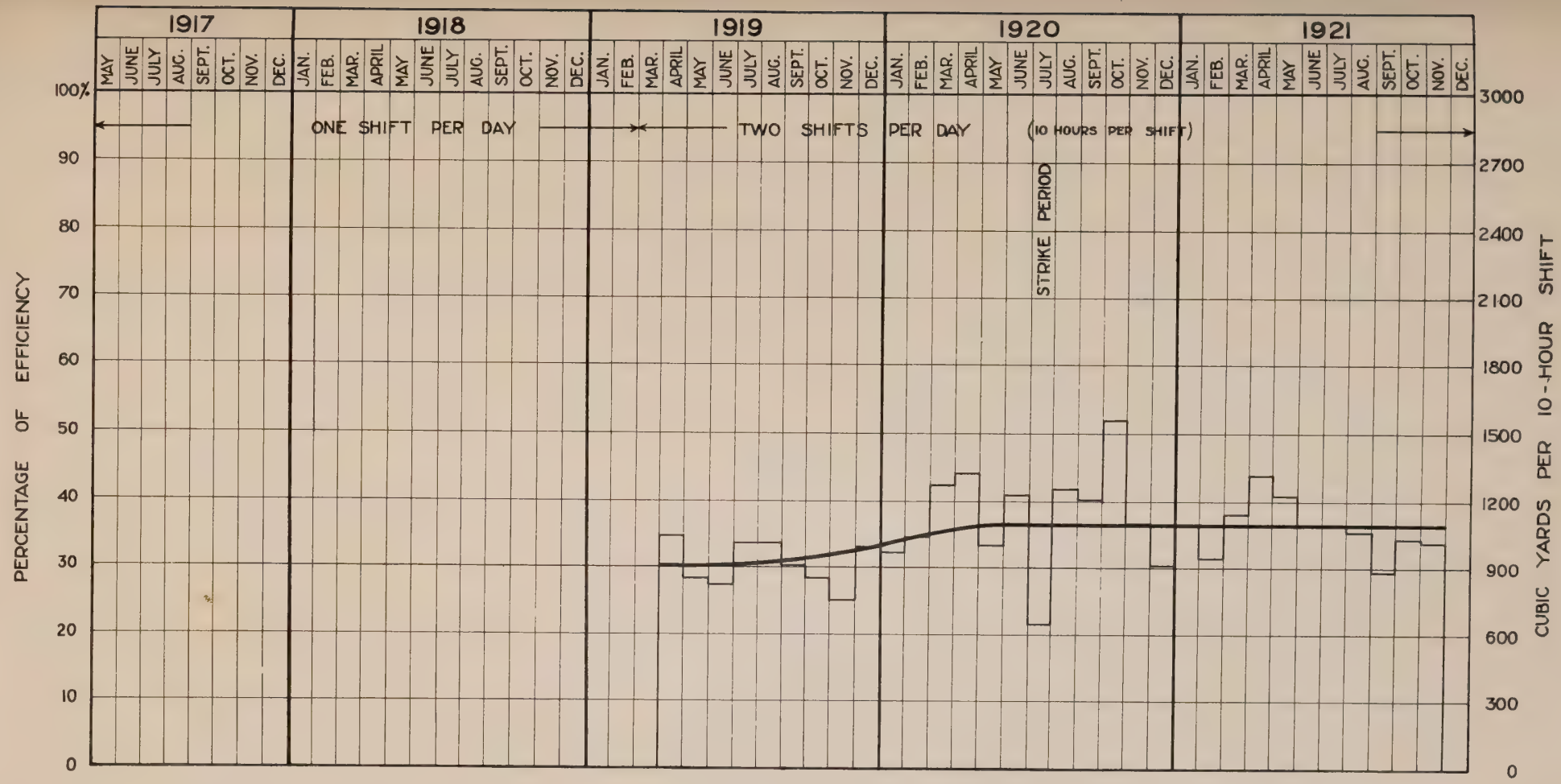
QUEENSTON-CHIPPAWA POWER DEVELOPMENT

ELECTRIC SHOVELS 1, 2 AND 8, TYPE 225-B PERFORMANCE CURVES IN EARTH EXCAVATION

Toronto, Oct. 31st, 1923. Made by WDA, Checked by J.

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

(M-Add-8)



THE EFFICIENCY PERCENTAGES ARE BASED ON 3,000 CUBIC YARDS PER SHOVEL PER 10-HOUR SHIFT IN ROCK AS BEING 100 PER CENTUM. (AS ASSUMED IN H. E. P. C. ESTIMATE No. 2.)

THE MONTHLY AVERAGE PERFORMANCE PER SHOVEL PER 10-HOUR SHIFT IS SHOWN THUS:

THE PROGRESSIVE AVERAGE PERFORMANCE PER SHOVEL IS SHOWN THUS:

HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
QUEENSTON-CHIPPAWA POWER DEVELOPMENT

ELECTRIC SHOVELS 1, 2 AND 8, TYPE 225-B PERFORMANCE CURVES IN ROCK EXCAVATION

Toronto, Oct. 31st, 1923. Made by WM, Checked by J.

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

(M-Add-9)

The Addenda referred to on the preceding pages, M-Add-1 to M-Add-9 inclusive, relating to History, to Supplementary Descriptive Photographs and to Electric Shovel Output, were placed at the end of Chapter M, and transmitted this day.

COPY Walter J. Francis

Consulting Engineer.

Toronto, October 31st, 1923.